Design of Beams using First Principles. & Drawing Reinforcement in Cross section.

نسألكم الدعاء

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Design of Beams using First Principles. Table of Contents.

Design of Beams using
Limits states Design Method.

التصميم بطريقه حالات الحدود .

Design using Limits states Design Method. (*L.S.D.M.*)

يتم التصميم بحيث نضمن أن المنشأ لن يتعدى أى حاله من حالات الحدود التاليه :

١- حد المقاومه القصوى *1 – Ultimate Strength Limit State.*

اذا تعدت الاجهادات حدود المقاومه القصوى للمواد ممكن بعدها ان يحدث انهيار .

٢- حد الاستقرار . *2 – Stability Limit State.*

لاستقرار المنشأ توجد عده عوامل يجب التأكد انها لن تزيد عن الحد الاقصى لها
مثل الانبعاج (*Buckling*) و مثل الانقلاب (*Overturning*)
و مثل الانزلاق (*Sliding*) و مثل الرفع لاعلى (*Uplift*)

اذا كانت اى حاله من الحالات السابقه تعدت الحد الاقصى لها
ممكن بعدها أن يحدث أنهيار للمنشأ ناتج عن عدم الاتزان .

٣- حد التشغيل . *3 – Serviceability Limit State.*

و هى حدود مثل :

حد التشكيل و الترخيم *Deformation & Deflection Limit State.*

حد التشرخ . *Cracking Limit State.*

اذا زاد مقدار التشكيل و الترخيم او عرض الشروخ عن حدود التشغيل
سيؤثر ذلك على استخدام عناصر المنشأ و فى بعض الاحيان يؤثر على سلامته .

Design of Beams.

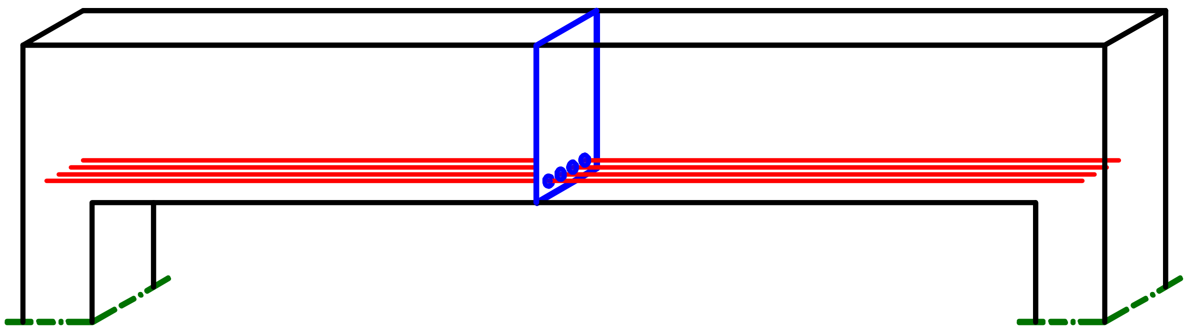
تصميم الكمره هو تحديد الابعاد الخرسانيه و كميه حديد التسليح اللازم لمقاومه أكبر عزم ممكن أن يؤثر عليها .

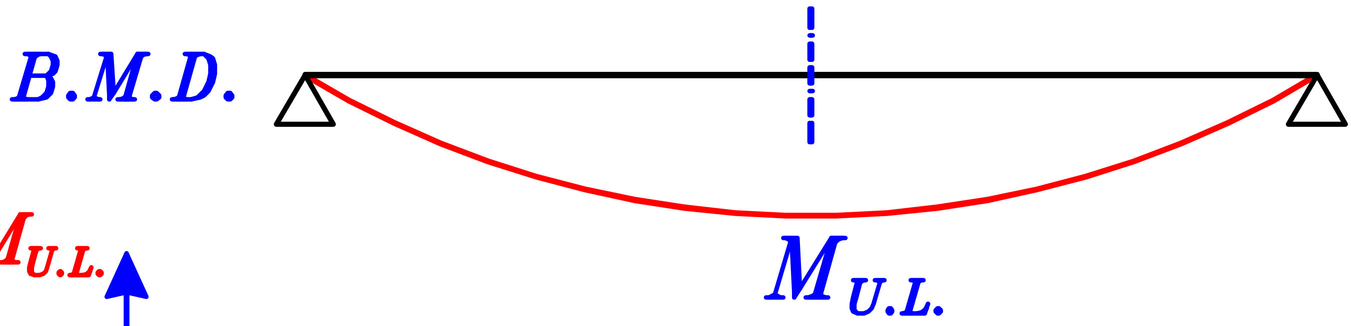
و نصمم فى الكمره القطاعات التى تسمى *Critical Sections* و هى القطاعات التى يؤثر عليها أكبر *moment* سفلى و اكبر *moment* علوى .

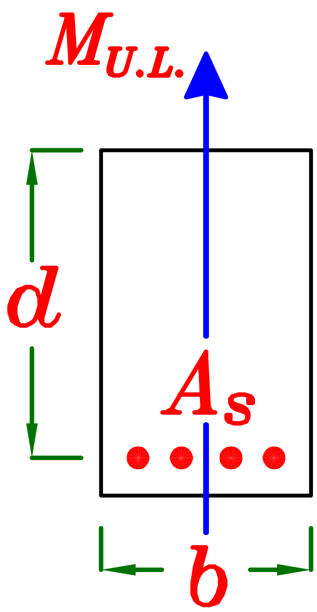
لتصميم هذه القطاعات نحدد ابعاد القطاع و كميه الحديد اللازمه لمقاومه الـ *moment* المؤثر على القطاع .

ثم نكمل باقى قطاعات الكمره بنفس ابعاد هذا القطاع و نكمل الحديد بنفس كميه حديد هذا القطاع .

فنضمن بهذا ان باقى القطاعات *safe* لانه سيكون عليها *moment* اقل مما ستتحمله .







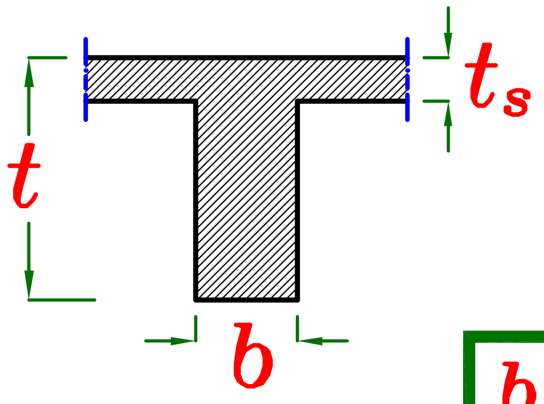
نصمم القطاع ليتحمل $M_{U.L.}$ المؤثر عليه .

نفرض قيمه b و نحدد قيمه كلا من d, A_s من التصميم .

لمقاومه $M_{U.L.}$ اذا اخترنا قيمه d كبيره ستكون الـ A_s صغيره .

و اذا اخترنا قيمه d صغيره ستكون الـ A_s كبيره .

لتصميم الكمرات توجد عده اشتراطات .



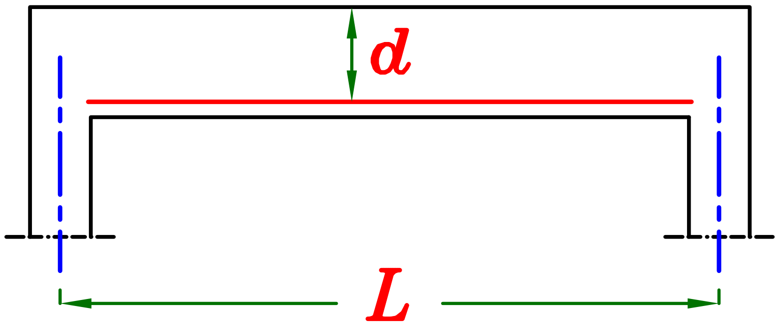
$$t \nless 3\, t_s$$

حتى نضمن ان الكمره هى التى تحمل البلاطه

$$b \nless 100\, mm$$

$$b \nless 0.75\, t_s$$

حتى نضمن عدم حدوث انبعاج جانبى للكمره



IF $\boxed{\dfrac{L}{d} > 4.0} \longrightarrow$ **Slender Beam.**

IF $\boxed{\dfrac{L}{d} \leq 4.0} \longrightarrow$ **Deep Beam.**

كل الكمرات التى سيتم دراستها فى هذه الملفات هى Slender Beams

Factor Of Safety (F.O.S.)

* F.O.S. For Loads.

عند التصميم يتم ضرب قيم القوى المؤثره على المنشأ فى معاملات (Factors)
حتى نعمل على زياده ال bending moments على الكمرات
بحث يتم التصميم على قيم bending moments اكبر من القيم الفعليه
فتكون ابعاد القطاعات و كميات حديد التسليح المستنتجه من ال design كبيره
مما يعمل على زياده الامان فى المبنى .

Types of Loads.

1- Dead Loads (D)	الاحمال الميته
2- Live Loads (L)	الاحمال الحيه
3- Wind Loads (W)	الاحمال الناتجه عن تأثير الرياح على المبنى
4- Seismic Loads (S)	الاحمال الناتجه عن تأثير الزلازل على المبنى

Cases of Loading.

و هى عباره عن احتمال جمع الاحمال المختلفه على المبنى فى نفس الوقت
بحيث تنتج اكبر bending moments ممكن ان تؤثر على الكمرات لنصمم عليها .
و يتم ضرب قيمه كل قوه من القوى المؤثره على المبنى فى Factor ثم جمعهم .

عند التصميم يتم ضرب قيم القوى المؤثره على المنشأ فى معاملات

1− IF Dead & Live Loads

To Increase Loads $= 1.4*D + 1.6*L$

or $= 1.5*(D+L)$ IF $L \leqslant 0.75\ D$

To Decrease Loads $= 0.9*D$

2− IF Dead , Live & Wind Loads.

$$= 0.8*(1.4*D + 1.6*L + 1.6*W)$$

3− IF Dead , Live & Seismic Loads.

$$= 0.8*(1.4*D) + \alpha*L + S$$

$\alpha = 0.25$ فى حاله المبانى السكنيه

$\alpha = 0.50$ فى حاله المدارس و المستشفيات و المسارح و الجراجات

$\alpha = 1.0$ فى حاله الصوامع و الخزانات و المكتبات و المخازن

فى حاله وجود احمال ناشئه عن الرياح و احمال ناشئه عن الزلازل

نأخذ فقط الحمل الاكبر منهما و لا يجوز جمع أحمال الرياح و الزلازل معاً

$$\left.\begin{array}{l} = 0.8*(1.4*D + 1.6*L + 1.6*W) \\ = 0.8*(1.4*D) + \alpha*L + S \end{array}\right] \text{الاكبر}$$

ملحوظه فى هذا الملف سيم دراسه تصميم الكمرات على الاحمال الرأسيه فقط اى الاحمال الميته و الحيه فقط. بدون احمال رياح او زلازل حيث سيتم دراستهم لاحقا .

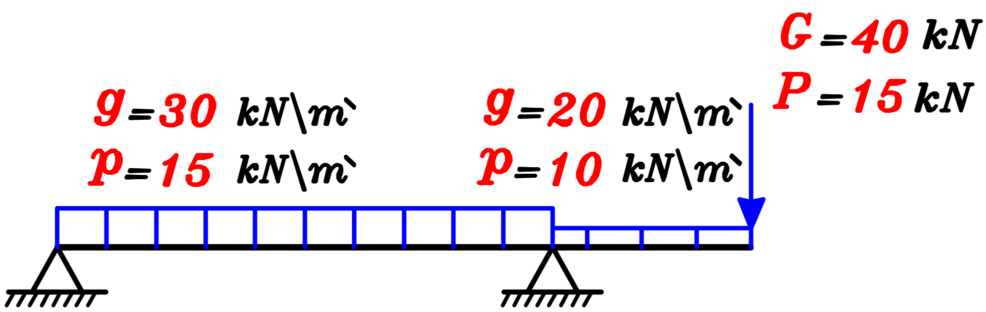
Cases of Loading due to Dead & Live Loads.

Load (To Increase) $= 1.4\ D.L. + 1.6\ L.L.$

$= 1.5\ (D.L. + L.L.)$ IF $L.L. \leqslant 0.75\ D.L.$

Load (To Decrease) $= 0.9\ D.L.$

Example.



Make Cases of Loading To draw max.−max. B.M.D. in U.L. Design Method

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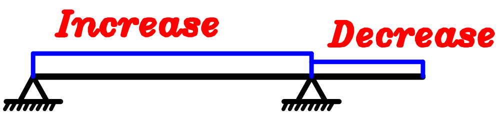
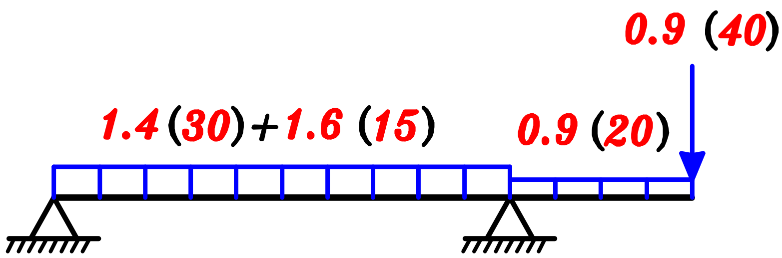
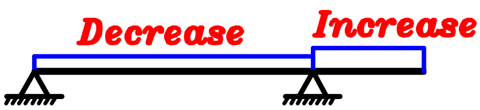
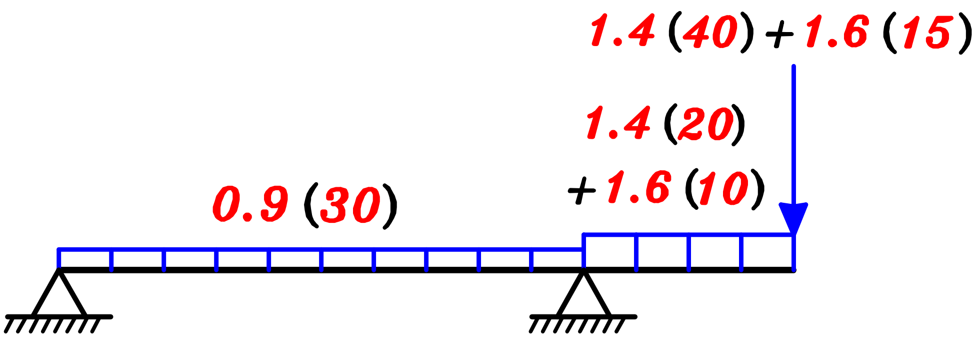
max. +Ve B.M.





max. −Ve B.M.





* F.O.S. For Materials.

1- Case of bending moment only (M) or Tension only (T) or Axial tension & bending moment $(M+T)$ or Shear (Q) only or Torsion only (M_t) or Shear & Torsion $(Q+M_t)$

$$\boxed{\gamma_c = 1.5 \quad , \quad \gamma_s = 1.15}$$ ✓✓

2- Case of Axial compression Force only. (P).

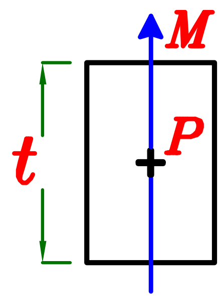
$$\boxed{\gamma_c = 1.75 \quad , \quad \gamma_s = 1.34}$$

3- Case of Axial compression Force and bending moment $(M+P)$

$$\boxed{e = \frac{M}{P}}$$

$$\gamma_c \ (\text{Concrete}) = 1.5 \left[\left(\frac{7}{6}\right) - \frac{(e \backslash t)}{3} \right] \geq 1.5$$

$$\gamma_s \ (\text{Steel}) = 1.15 \left[\left(\frac{7}{6}\right) - \frac{(e \backslash t)}{3} \right] \geq 1.15$$



$\therefore$ **Allowable stress For Concrete** $= \dfrac{F_{cu}}{\gamma_c}$

Allowable stress For Steel $= \dfrac{F_y}{\gamma_s}$

We have three types of Sections.

$$\boxed{C_b = \frac{600}{600 + (F_y \backslash \gamma_s)} * d}$$

1- **Balanced Section.** $\boxed{C = C_b}$

(Brittle Failure)

2- **Under Reinforced Section.** $\boxed{C < C_b}$

(Ductile Failure)

3- **Over Reinforced Section.** $\boxed{C > C_b}$

(Brittle Failure)

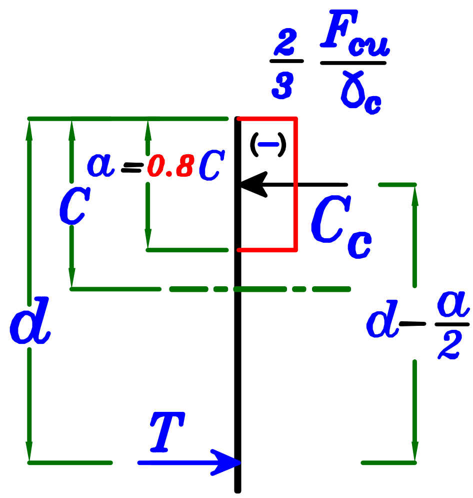
ملحوظه مهمه جدا

دائماً فى التصميم بطريقه ال U.L.D.M. يجب أن يكون القطاع

Under Reinforced Section.

Properties of Under Reinforced Section.

① $c \leqslant c_{max.}$



where: $$c_{max} = \frac{2}{3}\, c_b$$

$$\therefore\; c_{max} = \frac{2}{3}\left[\frac{600}{600+(F_y \backslash \gamma_s)} * d\right]$$

② $a \leqslant a_{max.}$

$$a_{max.} = 0.8\; c_{max.}$$

$$\therefore\; a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600+(F_y \backslash \gamma_s)} * d\right]$$

③ $a \geqslant a_{min}$

$$a_{min} = 0.1\; d$$

IF $a < 0.1\; d \xrightarrow{Take} a = 0.1\; d$

④ $A_s \leqslant A_{s\,max.}$

Where: $$\mu = \frac{A_s}{bd} = \frac{\text{مساحة الحديد الرئيسي}}{\text{مساحة الخرسانة}}$$

$\mu_{max.} = \frac{A_{s\,max.}}{bd} \longrightarrow$ Code Page (4−7) Table (1−4)

$$A_{s\,max.} = \mu_{max.}\, b\; d$$

⑤ $A_s \geqslant A_{s\,min.}$

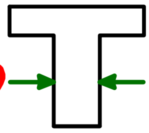
$$\mu_{min.} = \left\{ \begin{array}{l} \dfrac{1.1}{F_y} \\ 0.225 * \dfrac{\sqrt{F_{cu}}}{F_y} \end{array} \right\} \text{الأكبر}$$

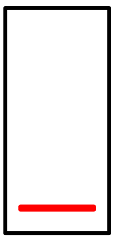
اذا كان $\boxed{F_{cu} \geqslant 25\ N/mm^2}$

تكون $\boxed{0.225 * \dfrac{\sqrt{F_{cu}}}{F_y}}$ هى الاكبر

دائما نقارن قيمه $A_{s\,req.}$ المحسوبه من التصميم بقيمه $\boxed{\mu_{min.} * b * d}$

حيث b هى اصغر عرض فى القطاع

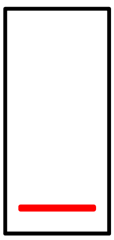
b 



$A_{s\,req.}$

١ـ اذا كانت $A_{s\,req.} \geqslant \mu_{min.} * b * d$

نضع قيمه $A_{s\,req.}$ فى الكمره و تنفذ على ذلك .



$A_{s\,min}$

٢ـ اذا كانت $A_{s\,req.} < \mu_{min.} * b * d$

نضع قيمه $A_{s\,min}$ فى الكمره و تنفذ على ذلك .

حيث قيمه $A_{s\,min}$ التى تضمن التحكم فى تشرخ الكمره و ضمان وجود ممطوليه

$$A_{s\,min.} \ (\text{For Beams}) = \left\{ \begin{array}{l} \left\{ \begin{array}{l} \mu_{min.}\ b\ d \\ 1.3\ A_{s\,req.} \end{array} \right\} \text{الأقل} \\ \begin{array}{l} st.\ 360/520 \\ st.\ 400/600 \end{array} \quad \dfrac{0.15}{100}\ b\ d \\ st.\ 240/350 \quad \dfrac{0.25}{100}\ b\ d \end{array} \right\} \text{الأكبر}$$

Example.

$F_{cu} = 25 \ kN/m^2$, $F_y = 360 \ kN/m^2$

From design of a given Sec. $(250 * 700)$

Found that $A_{s\,req.} = 300 \ mm^2$ Check $A_{s\,min.}$

$$\mu_{min.} = \left\{ \begin{array}{l} \dfrac{1.1}{F_y} \\[2ex] 0.225 * \dfrac{\sqrt{F_{cu}}}{F_y} = \dfrac{1.125}{F_y} \end{array} \right\} = \overset{\text{الأكبر}}{\dfrac{1.125}{F_y}}$$

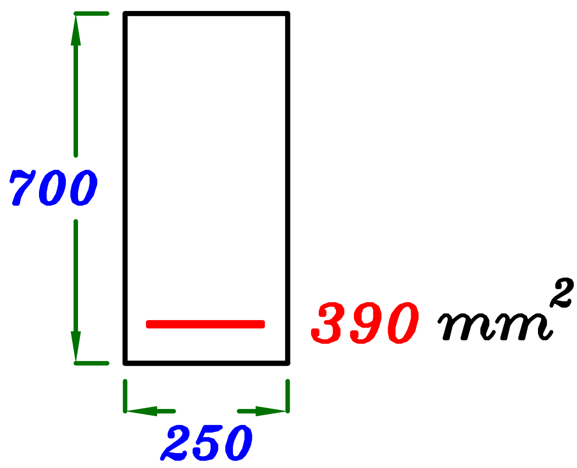
Calculate

$$\mu_{min.} \, b \, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b \, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 650 = 507.8 \ mm^2$$

$$\therefore A_{s\,req.} < A_{s\,min.} \quad \therefore \quad \text{Take } A_s = A_{s\,min.}$$

$$\left.\begin{array}{l} A_{s\,min.} = 0.225 * \dfrac{\sqrt{F_{cu}}}{F_y} \, b \, d = \left(0.225 * \dfrac{\sqrt{25}}{360}\right) 250 * 650 = 507.8 \\[2ex] 1.3 \, A_{s\,req.} = 1.3 * 300 = 390 \end{array}\right\} \overset{\text{الأقل}}{= 390}$$

$$\left.\begin{array}{l} \overset{\text{الأقل}}{= 390} \\[2ex] \text{st. } 360/520 \qquad \dfrac{0.15}{100} \, b \, d = \dfrac{0.15}{100} * 250 * 650 = 243.7 \end{array}\right\} \overset{\text{الأكبر}}{= 390 \ mm^2}$$



⑥ $A_{s`} \leqslant A_{s`_{max.}}$ IF we are using $A_{s`}$

where $\boxed{A_{s`_{max.}} = 0.4 A_s}$

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⑦ $d \geqslant d_{min.}$

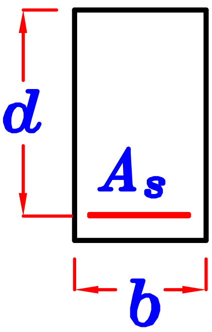
$d_{min.}$ هو أقل عمق للقطاع يكون فية القطاع Under Reinforced Section

و إذا قلت قيمة ال d عن ال $d_{min.}$ يصبح القطاع Over Reinforced Section

IF $M_{U.L.}$ is given , We can get $d_{min.}$ by using

without $A_{s`}$

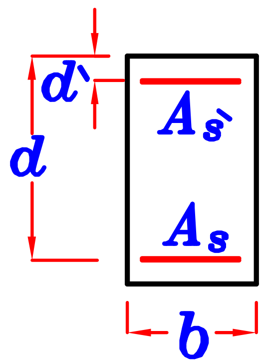
$$\boxed{\begin{aligned} M_{U.L.} &= \frac{2}{3} \frac{F_{cu}}{\gamma_c} a_{max} \, b \left(d_{min.} - \frac{a_{max}}{2}\right) \\ \text{OR} \quad M_{U.L.} &= R_{max.} \frac{F_{cu}}{\gamma_c} \, b \, d_{min.}^2 \end{aligned}}$$



Code Page (4–6) Table (4–1)

IF $M_{U.L.}$ is given , by using $A_{s`}$

$$\boxed{\begin{aligned} M_{U.L.} &= \frac{2}{3} \frac{F_{cu}}{\gamma_c} a_{max} \, b \left(d_{min} - \frac{a_{max}}{2}\right) + A_{s`} \frac{F_y}{\gamma_s} (d_{min} - d`) \\ \text{OR} \quad M_{U.L.} &= R_{max.} \frac{F_{cu}}{\gamma_c} \, b \, d_{min.}^2 + A_{s`} \frac{F_y}{\gamma_s} (d_{min} - d`) \end{aligned}}$$



⑧ $M_{U.L.} \leqslant M_{U.L.max}$

اذا كان معطى عمق القطاع $d = \checkmark$ يجب أن لا يزيد العزم المؤثر عن $M_{U.L._{max}}$

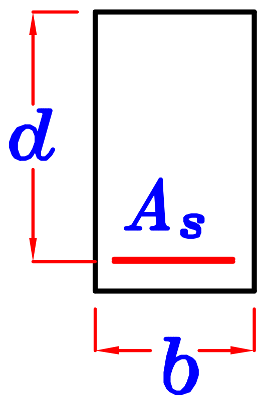
اذا زادت قيمة العزم المؤثر عن $M_{U.L._{max}}$ يصبح القطاع Over Reinforced Section

IF d is given , We can get $M_{U.L._{max}}$ by using

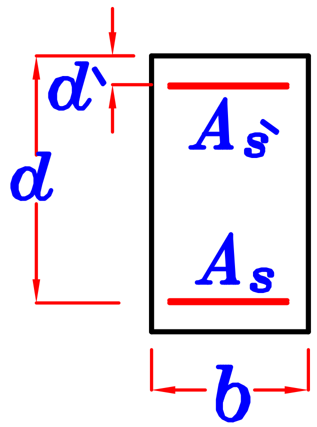
without $A_{s`}$

$$M_{U.L._{max}} = \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\,a_{max}\,b\left(d - \frac{a_{max}}{2}\right)$$

$$\text{OR}\quad M_{U.L._{max}} = R_{max.}\,\frac{F_{cu}}{\gamma_c}\,b\,d^2$$



with $A_{s`}$



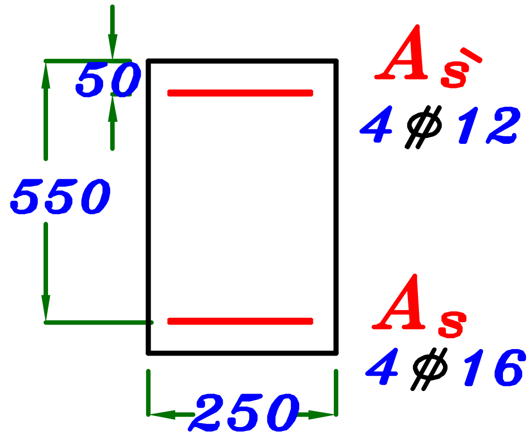
$$M_{U.L._{max}} = \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\,a_{max}\,b\left(d - \frac{a_{max}}{2}\right) + A_{s`}\,\frac{F_y}{\gamma_s}\,(d - d`)$$

$$\text{OR}\quad M_{U.L._{max}} = R_{max.}\,\frac{F_{cu}}{\gamma_c}\,b\,d^2 + A_{s`}\,\frac{F_y}{\gamma_s}\,(d - d`)$$

Example.

$F_{cu} = 25\ N/mm^2$ st. 360/520

Get $M_{U.L._{max}}$



$$A_s = 4\phi 16 = 804\ mm^2$$

$$A_{s`} = 4\phi 12 = 452\ mm^2$$

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \gamma_s)} * d\right]$$

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (\frac{360}{1.15})} * 550\right] = 192.7 mm$$

$$M_{U.L._{max}} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, a_{max}\, b\left(d - \frac{a_{max}}{2}\right) + A_{s`}\frac{F_y}{\gamma_s}(d - d`)$$

$$\therefore M_{U.L._{max}} = \frac{2}{3}\left(\frac{25}{1.5}\right)(192.7)(250)\left(550 - \frac{192.7}{2}\right) + 452\left(\frac{360}{1.15}\right)(550 - 50)$$

$$= 313576590\ N.mm = 313.576\ kN.m$$

OR Get $R_{max.} = 0.194$ Code Page (4–7) Table (1–4)

$$M_{U.L._{max}} = R_{max.}\frac{F_{cu}}{\gamma_c}\, b\, d^2 + A_{s`}\frac{F_y}{\gamma_s}(d - d`)$$

$$M_{U.L._{max}} = 0.194\left(\frac{25}{1.5}\right)(250)(550)^2 + 452\left(\frac{360}{1.15}\right)(550 - 50)$$

$$= 315268659\ N.mm = 315.268\ kN.m$$

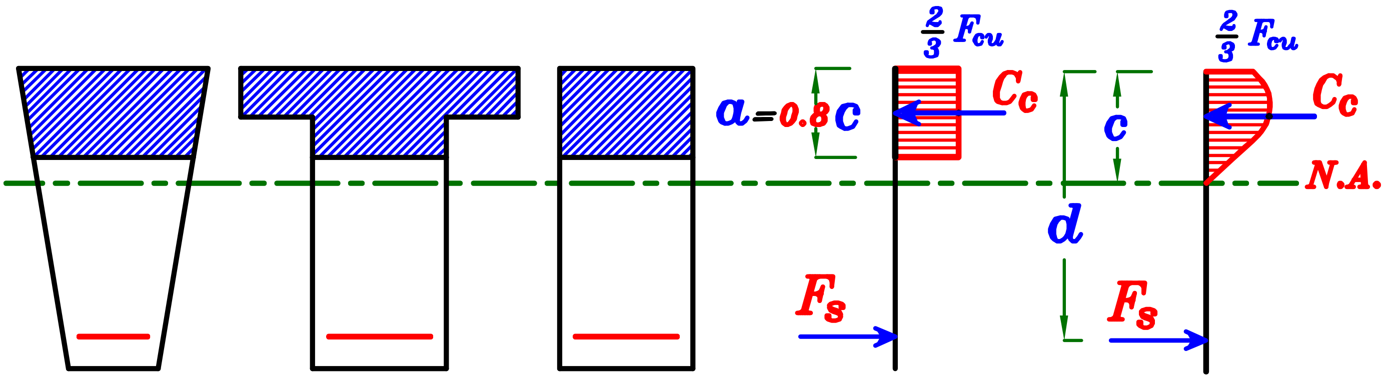
يوجد فى الكود المصرى جدول يعطى قيم لمعلملات R_{max} & μ_{max} , $\frac{c_{max}}{d}$

Code Page (4−6) Table (4−1)

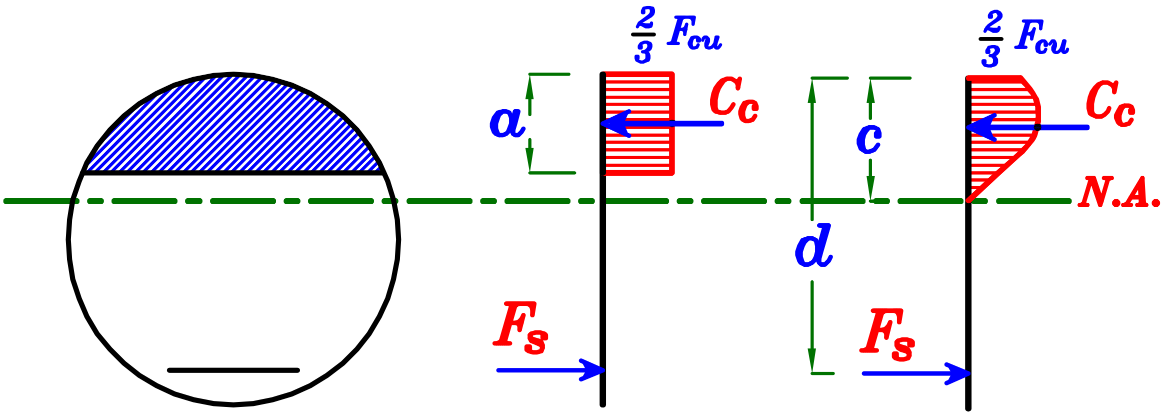
رتبه الحديد	$\frac{c_{max}}{d}$	μ_{max}	R_{max}
st. 240/350	0.50	$8.56 \times 10^{-4} \times F_{cu}$	0.214
st. 280/450	0.48	$7.0 \times 10^{-4} \times F_{cu}$	0.208
st. 360/520	0.44	$5.0 \times 10^{-4} \times F_{cu}$	0.194
st. 400/600	0.42	$4.31 \times 10^{-4} \times F_{cu}$	0.187
st. 450/520	0.40	$3.65 \times 10^{-4} \times F_{cu}$	0.180

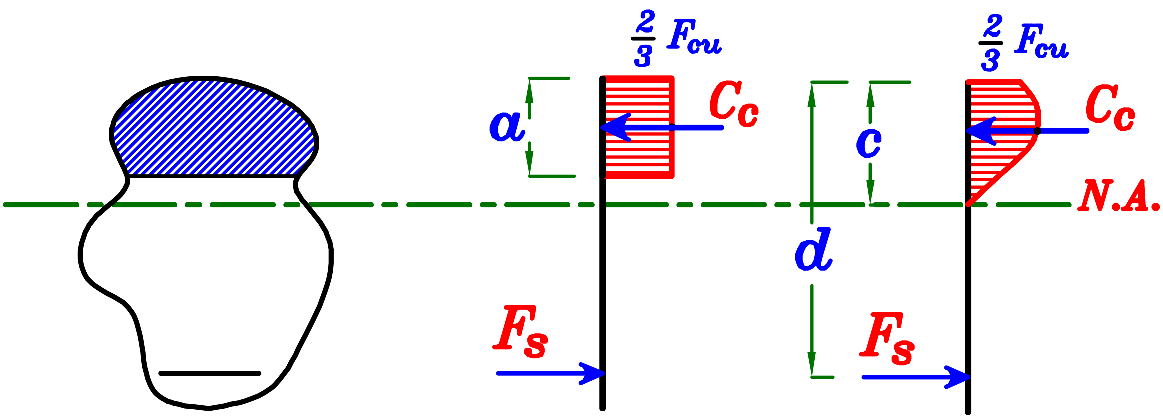
ملحوظه .

شكل ال *Equivalent Stress* المستنتج بحيث تكون قيمه و مكان محصله القوى له تساوى نفس قيمه و مكان محصله ال *Actual Stress* للقطاعات *R-Sec, T-Sec., L-Sec. & Trapezoidal Sec.* تكون قيمه $\boxed{a = 0.8\ C}$



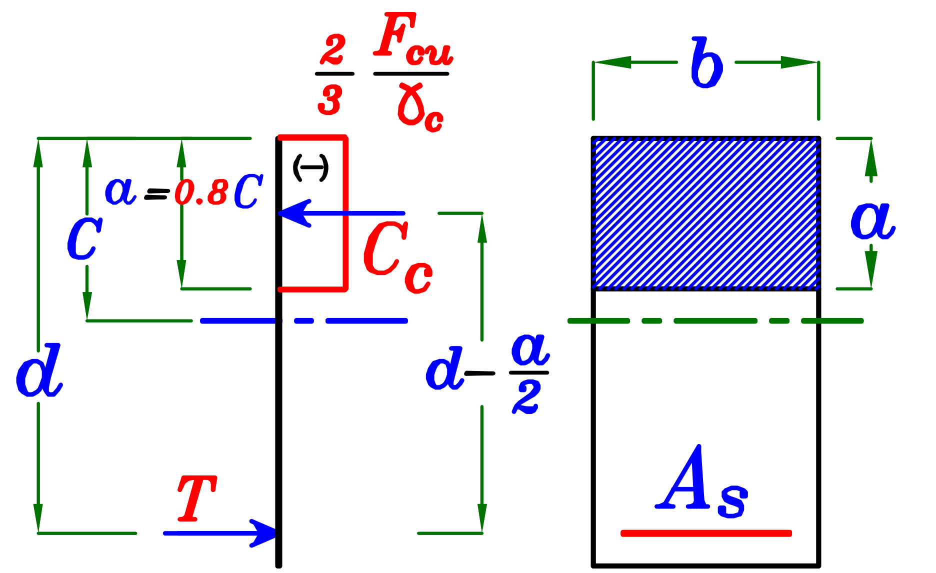
اما اى شكل اخر مثل القطاعات الدائريه او غير منتظمه الشكل فيجب علينا لتحديد قيمه a التى تجعل قيمه و مكان محصله القوى على الخرسانه لشكل ال *Equivalent Stress* هى نفس قيمه و مكان محصله القوى على الخرسانه لل *Actual Stress* و ذلك عن طريق التكامل . $\boxed{a \neq 0.8\ C}$





و فى هذا الملف سنتناول دراسه القطاعات المنتظمه فقط
R-Sec, T-Sec., L-Sec. & Trapezoidal Sec.

Design of R-Section Subjected to B.M. only Using First Principles.



نبدأ دائما بهذه المعادله لتحديد قيمه d أو a

$M = C *$ المسافه حتى الحديد

$$\boxed{M_{U.L.} = \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\,a\,b\left(d-\frac{a}{2}\right)} \qquad a\,,d$$

نعوض فى هذه المعادله اذا كان $a \geq 0.1\,d$ و ذلك لتحديد قيمه A_s

$$C = T$$

$$\boxed{\frac{2}{3}\,\frac{F_{cu}}{\gamma_c} * a * b = A_s * \frac{F_y}{\gamma_s}} \qquad a\,,A_s$$

نعوض فى هذه المعادله اذا كان $a < 0.1d$ و ذلك لتحديد قيمه A_s

مع أخذ قيمه $a = 0.1d$

$M = T *$ المسافه حتى الخرسانه

$$\boxed{M_{U.L.} = A_s\,\frac{F_y}{\gamma_s}\left(d-\frac{a}{2}\right)} \qquad a\,,d\,,A_s$$

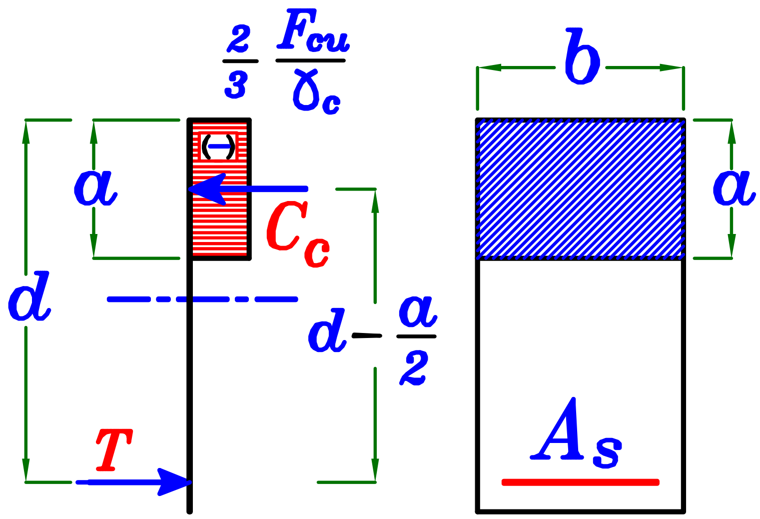
Types of Problems.

Type (1)

Given: F_{cu} , st. , b , $M_{U.L.}$

Req: d , A_s

Solution:



- $a_{min} = 0.1\, d$

- $a_{max} = 0.8\left(\frac{2}{3}\right) C_b$

$$= 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600+(F_y \backslash \delta_s)}\right] * d$$

- Choose a value between a_{min}, a_{max} $\boxed{a = \checkmark * d}$

- From $M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\delta_c}\, a\, b\left(d-\frac{a}{2}\right)$

$$M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\delta_c}(\checkmark d)\, b\left(d-\frac{(\checkmark d)}{2}\right) \xrightarrow{get} d$$

تقرب d لأقرب ٥٠ مم بالزيادة

- $\boxed{t = d + 50\ mm = \checkmark}$

قبل التقريب

- Get $a = (\checkmark\, d)$

- Get A_s From $\frac{2}{3}\frac{F_{cu}}{\delta_c} * a * b = A_s * \frac{F_y}{\delta_s}$

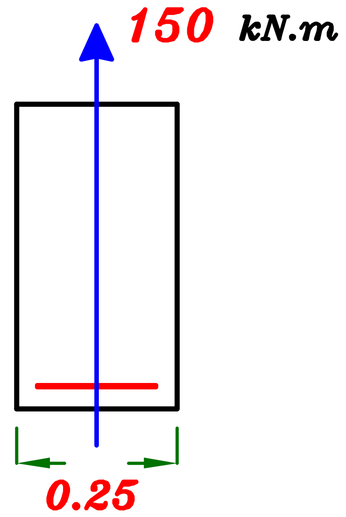
- Check $A_{s\,min}$

Example.

$F_{cu} = 25\ N\backslash mm^2$ st. 360/520

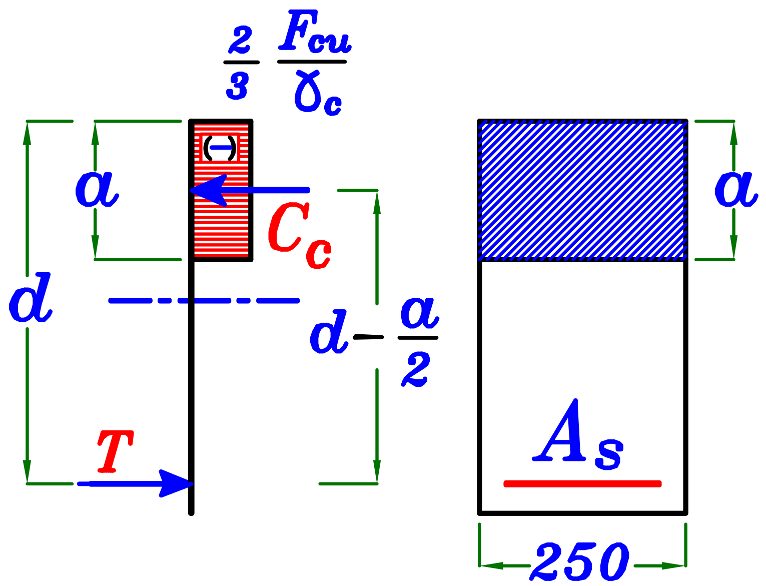
$b = 0.25\ m$ R-Sec.

$M_{U.L.} = 150\ kN.m$



Req: Get d , A_s

Solution.



— $a_{min} = 0.1\ d$

— $a_{max} = 0.8\left(\frac{2}{3}\right) C_b = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \gamma_s)}\right] * d$

$$= 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (360 \backslash 1.15)}\right] * d = 0.35\ d$$

— Choose a value between a_{min} , a_{max} $\therefore$ Take $\boxed{a = (0.25\,d)}$

— From $M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, a\, b\left(d - \frac{a}{2}\right)$

$$150 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(0.25\,d)(250)\left(d - \frac{0.25\,d}{2}\right)$$

$\therefore d = 496.8\ mm$ $\therefore$ $\boxed{d = 500\ mm}$

$\boxed{t = 500 + 50 = 550\ mm}$

قبل التقريب

- Get $a = 0.25\, d = 0.25 * 496.8 = 124.2$ mm

- Get A_s From $\frac{2}{3}\frac{F_{cu}}{\gamma_c} * a * b = A_s * \frac{F_y}{\gamma_s}$

$$\frac{2}{3}\left(\frac{25}{1.5}\right)(124.2)(250) = A_s\left(\frac{360}{1.15}\right) \longrightarrow A_s = 1102.0 \text{ mm}^2$$

Check $A_{s_{min.}}$

$A_{s_{req.}} = 1102.0 \text{ mm}^2$

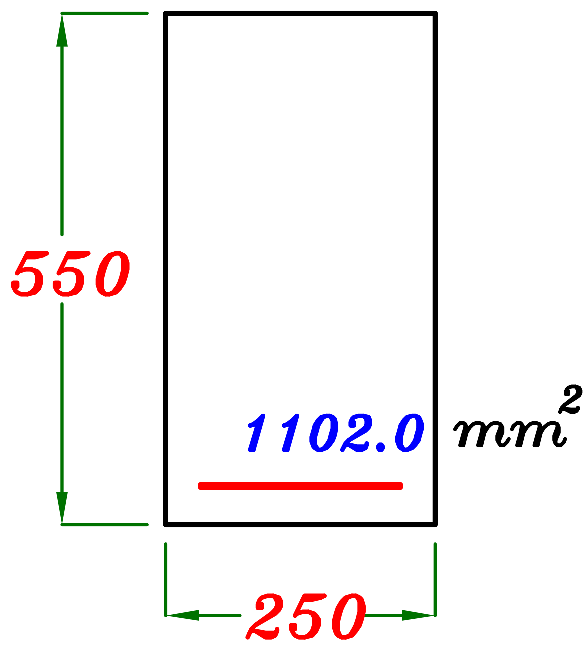
$\because F_{cu} = 25 \text{ N}\backslash\text{mm}^2$

بعد التقريب

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 500 = 390.6 \text{ mm}^2$$

$$\therefore A_{s_{req.}} > \mu_{min.}\, b\, d$$

$$\therefore \text{Take } A_s = A_{s_{req.}} = 1102.0 \text{ mm}^2$$



Type ②

Given: F_{cu} , st. , b , d , $M_{U.L.}$

Req: A_s , $A_{s'}$ IF Required.

Solution.

Calculate $a_{max} = 0.8\, C_{max} = 0.8\left(\frac{2}{3}\right) C_b = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \delta_s)}\right] * d$

Calculate $M_{U.L.\,max.} = \frac{2}{3}\,\frac{F_{cu}}{\delta_c}\, a_{max.}\, b\left(d - \frac{a_{max.}}{2}\right)$

* IF $M_{U.L.} \leqslant M_{U.L.\,max.} \longrightarrow$ No need to use Compression steel $(A_{s'})$

– Get a From

$$M_{U.L.} = \frac{2}{3}\,\frac{F_{cu}}{\delta_c}\, a\, b\left(d - \frac{a}{2}\right)$$

$\boxed{a}$

IF $a \leqslant 0.1\,d$

Take $a = 0.1\,d$

– Get A_s From

$$M_{U.L.} = A_s \frac{F_y}{\delta_s}\left(d - \frac{a}{2}\right)$$

$$M_{U.L.} = A_s \frac{F_y}{\delta_s}\left(d - \frac{0.1\,d}{2}\right)$$

– Check $A_{s\,min.}$

IF $a > 0.1\,d$

– Get A_s From

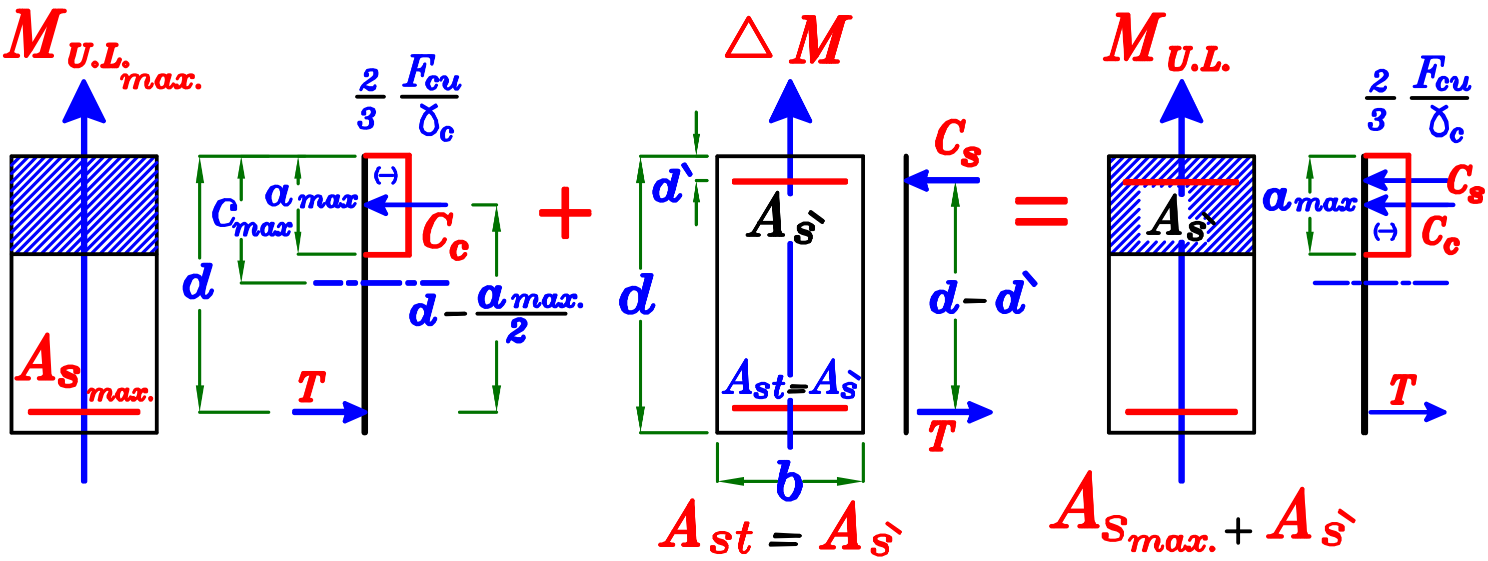
$$\frac{2}{3}\,\frac{F_{cu}}{\delta_c} * a * b = A_s * \frac{F_y}{\delta_s}$$

Check $A_{s\,min.}$

* IF $M_{U.L.} > M_{U.L._{max.}}$

∴ We need to use Compression steel ($A_{s`}$)

∴ We have to put a Compression Steel to be able to increase Tension Steel $A_s > A_{s_{max.}}$ and the Sec. still Under Reinforced Sec.



$$M_{U.L._{max.}} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, a_{max.}\, b\left(d - \frac{a_{max.}}{2}\right)$$

$$\triangle M = M_{U.L.} - M_{U.L._{max.}} = C_s\,(d-d`) = A_{s`}\frac{F_y}{\gamma_s}\,(d-d`)$$

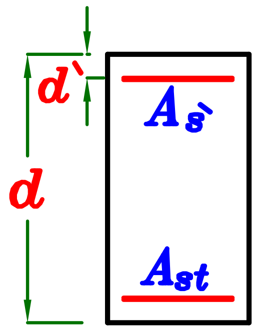
Conditions to use $A_{s`}$

1- $A_{s`_{max.}} = \dfrac{40}{100} A_s$ يفضل و ليس شرط

2- $\dfrac{d`}{d} \leqslant 0.20$ st. 240/350

$\leqslant 0.15$ st. 360/520

$\leqslant 0.10$ st. 400/600



* IF $M_{U.L.} > M_{U.L._{max.}}$

$\therefore$ We need to use Compression steel ($A_{s'}$)

_ Get $\triangle M = M_{U.L.} - M_{U.L._{max.}}$

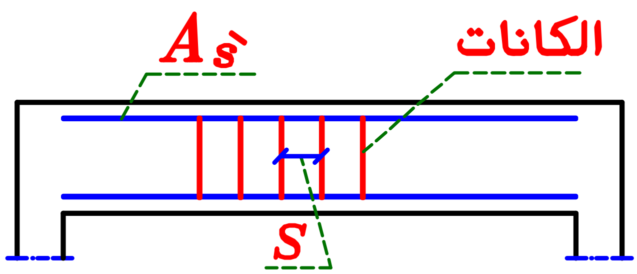
_ Get $A_{s'}$ From $\triangle M = A_{s'} \frac{F_y}{\gamma_s} (d-d')$

$$\therefore \boxed{A_s = A_{s_{max.}} + A_{s'} = \mu_{max.}\, b\, d + A_{s'}}$$

_ Check $A_{s'_{max.}} = 0.4\, A_s$

① IF $A_{s'} \leq A_{s'_{max.}} \longrightarrow$ o.k.

② IF $A_{s'} > A_{s'_{max.}} \longrightarrow$ we have to increase dimensions.



ملحوظه :

عند استخدام حديد فى الضغط $A_{s'}$

فى الكمرات ، يجب أن لا تزيد

المسافه S بين الكانات عن ١٥ قطر سيخ حديد الضغط $S \ngtr 15\, \phi$

حتى لا يحدث انبعاج (buckling) لحديد الضغط.

Type ②

Given: F_{cu}, st., b, d, $M_{U.L.}$

Req: A_s, A_s' IF Required

Calculate $a_{max} = 0.8\, C_{max} = 0.8\left(\frac{2}{3}\right) C_b = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \gamma_s)}\right] * d$

Calculate $M_{U.L._{max}} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, a_{max}\, b \left(d - \frac{a_{max}}{2}\right)$

$\boxed{M_{U.L.}}$

$\boxed{\text{IF } M_{U.L.} \leqslant M_{U.L._{max.}}}$

(No need to use A_s')

– Get a From

$M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, a\, b\left(d - \frac{a}{2}\right)$

$\boxed{a}$

IF $a \leqslant 0.1\, d$

Take $a = 0.1\, d$

– Get A_s From

$M_{U.L.} = A_s \frac{F_y}{\gamma_s}\left(d - \frac{0.1\, d}{2}\right)$

IF $a > 0.1\, d$

– Get A_s From

$\frac{2}{3}\frac{F_{cu}}{\gamma_c} * a * b = A_s * \frac{F_y}{\gamma_s}$

Check

$A_{s_{min.}} = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d$

$\boxed{\text{IF } M_{U.L.} > M_{U.L._{max.}}}$

(We need to use A_s')

– Get $\triangle M = M_{U.L.} - M_{U.L._{max.}}$

– Get A_s' From

$\triangle M = A_s' \frac{F_y}{\gamma_s}(d - d')$

– Get $\boxed{\begin{array}{l} A_s = A_{s_{max.}} + A_s' \\ A_s = \mu_{max.}\, b\, d + A_s' \end{array}}$

– Check $A'_{s_{max.}} = 0.4\, A_s$

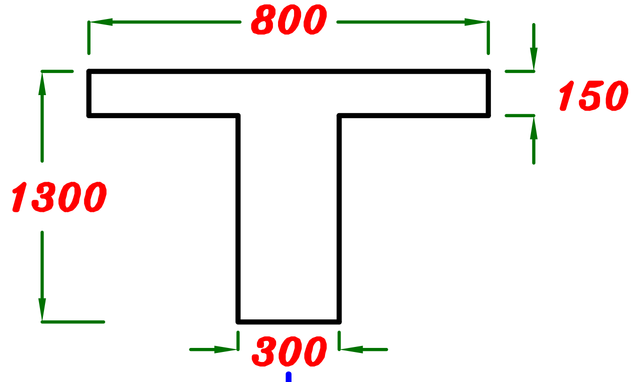
IF $A_s' \leqslant A'_{s_{max.}}$

o.k.

IF $A_s' > A'_{s_{max.}}$

Increase Dimensions

Example.

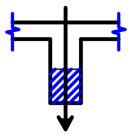


$M_{U.L.} = 400$ kN.m

$F_{cu} = 25$ N\mm^2 st. 360/520

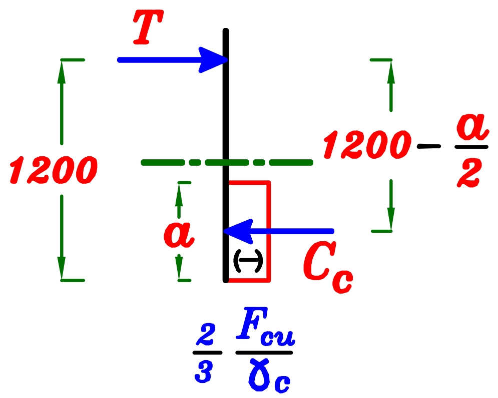
Req: Get A_s , $A_{s'}$ IF Required and draw Details of RFT. in Cross sec.

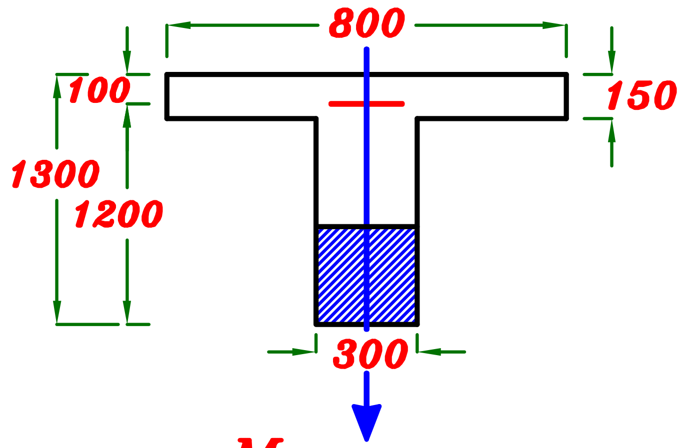
Solution.

R–Sec. 

When $t > 1000$ mm $\xrightarrow{\text{Take}}$ Cover $= 100$ mm

$$d = 1300 - 100 = 1200 \text{ mm}$$





$M_{U.L.} = 400$ kN.m

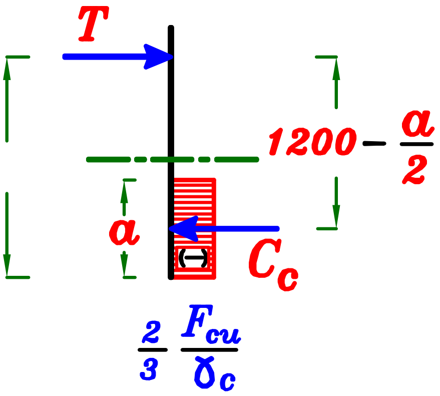
$$a_{min} = 0.10\, d = 0.10 * 1200 = 120 \text{ mm}$$

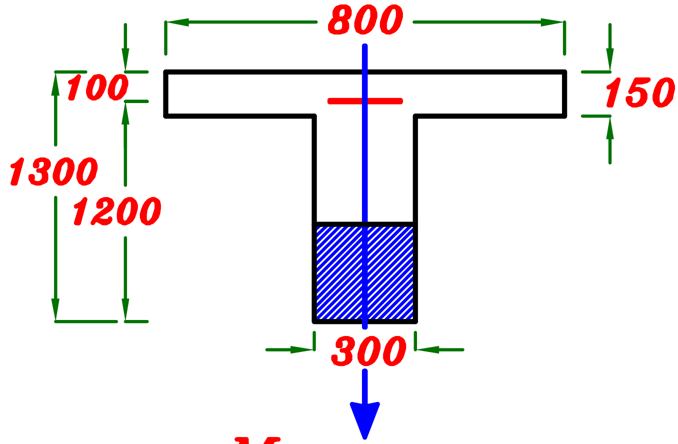
$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \gamma_s)}\right] * d = 0.35\, d = 0.35 * 1200 = 420 \text{ mm}$$

$$M_{U.L._{max}} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, a_{max}\, b\left(d - \frac{a_{max}}{2}\right)$$

$$= \frac{2}{3}\left(\frac{25}{1.5}\right)(420)(300)\left(1200 - \frac{420}{2}\right) = 1386000000 \text{ N.mm} = 1386 \text{ kN.m}$$

$\because M_{U.L.} < M_{U.L.\,max.}$ $\therefore$ No need to use $A_{s'}$





$M_{U.L.} = 400\ kN.m$

– Get a From $M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, a\, b\left(d - \frac{a}{2}\right)$

$\therefore\ 400*10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(a)(300)\left(1200 - \frac{a}{2}\right) \longrightarrow \boxed{a = 104.55\ mm} < 0.1\,d$

$\therefore$ Take $a = 0.1\,d$

– Get A_s From $M_{U.L.} = A_s \frac{F_y}{\gamma_s}\left(d - \frac{0.1\,d}{2}\right)$

$400*10^6 = A_s\left(\frac{360}{1.15}\right)\left(1200 - \frac{120}{2}\right) \longrightarrow \boxed{A_s = 1121\ mm^2}$

Check $A_{s_{min.}}$ $\qquad A_{s\ req.} = 1121\ mm^2$

$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 300 * 1200 = 1125\ mm^2$

$\therefore\ \mu_{min.}\, b\, d > A_{s\,req.} \xrightarrow{Use} A_{s_{min.}}$

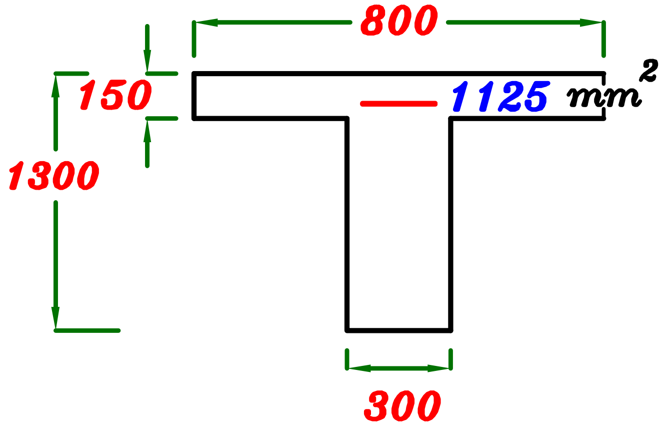
$A_{s_{min.}} = 0.225 * \frac{\sqrt{F_{cu}}}{F_y}\, b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 300 * 1200 = 1125$

$1.3\, A_{s\,req.} = 1.3 * 1121 = 1457$

$\left.\right\}$ = 1125 الأقل

st. 360/520 $\quad \frac{0.15}{100}\, b\, d = \frac{0.15}{100} * 300 * 1200 = 540$

$\left.\right\}$ = 1125 mm^2 الأكبر



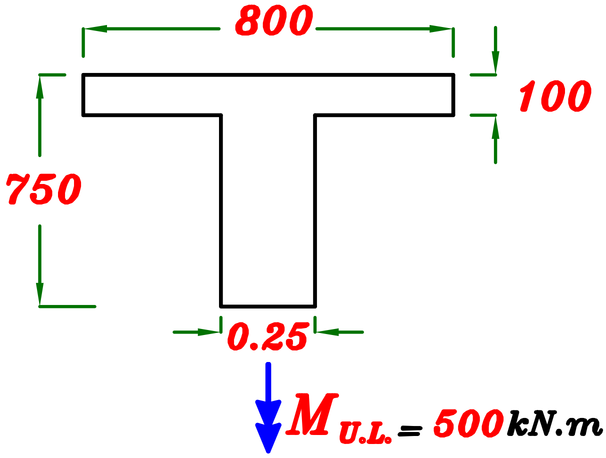
Example.

$F_{cu} = 25 \ N\backslash mm^2$ st. $360/520$

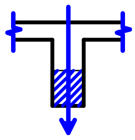
$M_{U.L.} = 500 \ kN.m$

$b = 0.25 \ m$ $d = 0.70 \ m$

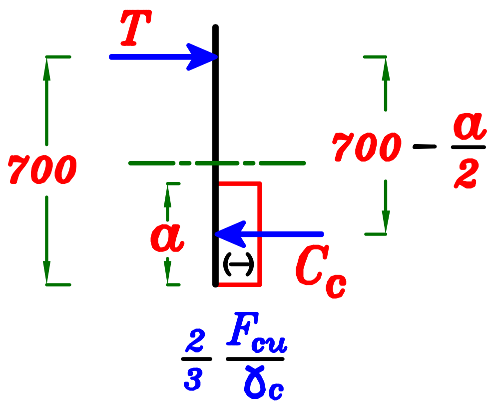
Get A_s , $A_{s`}$ IF Required

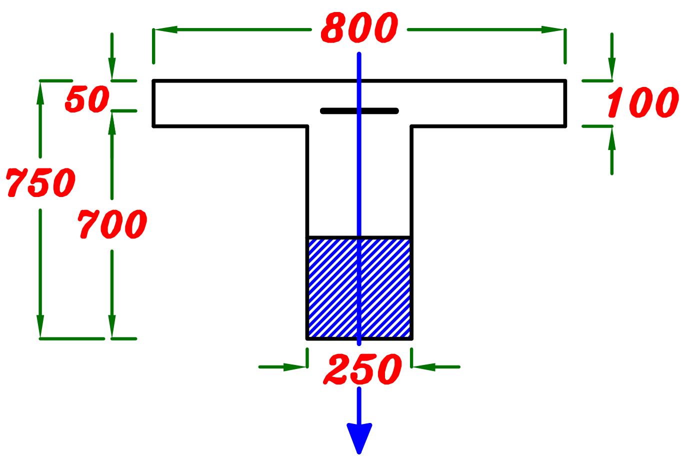


Solution.

R-Sec. 

$$d = 750 - 50 = 700 \ mm$$





$$a_{min} = 0.10 \, d = 0.10 * 700 = 70 \ mm$$

$$a_{max} = 0.8 \left(\frac{2}{3}\right) \left[\frac{600}{600 + (F_y \backslash \gamma_s)} \right] * d = 0.35 \, d = 0.35 * 700 = 245 \ mm$$

$$M_{U.L._{max}} = \frac{2}{3} \frac{F_{cu}}{\gamma_c} \, a_{max} \, b \left(d - \frac{a_{max}}{2}\right)$$

$$= \frac{2}{3} \left(\frac{25}{1.5}\right) (245)(250) \left(700 - \frac{245}{2}\right) = 393020833 \ N.mm = 393.0 \ kN.m$$

$\because M_{U.L.} > M_{U.L.max.}$ $\therefore$ We need to use $A_{s`}$

- Get $\Delta M = M_{U.L.} - M_{U.L._{max.}} = 500 - 393 = 107$ kN.m

- Get $A_{s`}$ From $\Delta M = A_{s`} \frac{F_y}{\gamma_s}(d-d`)$

$\therefore 107 * 10^6 = A_{s`}\left(\frac{360}{1.15}\right)(700-50) \longrightarrow \boxed{A_{s`} = 525\ mm^2}$

From Code Page (4–6) Table (4–1)

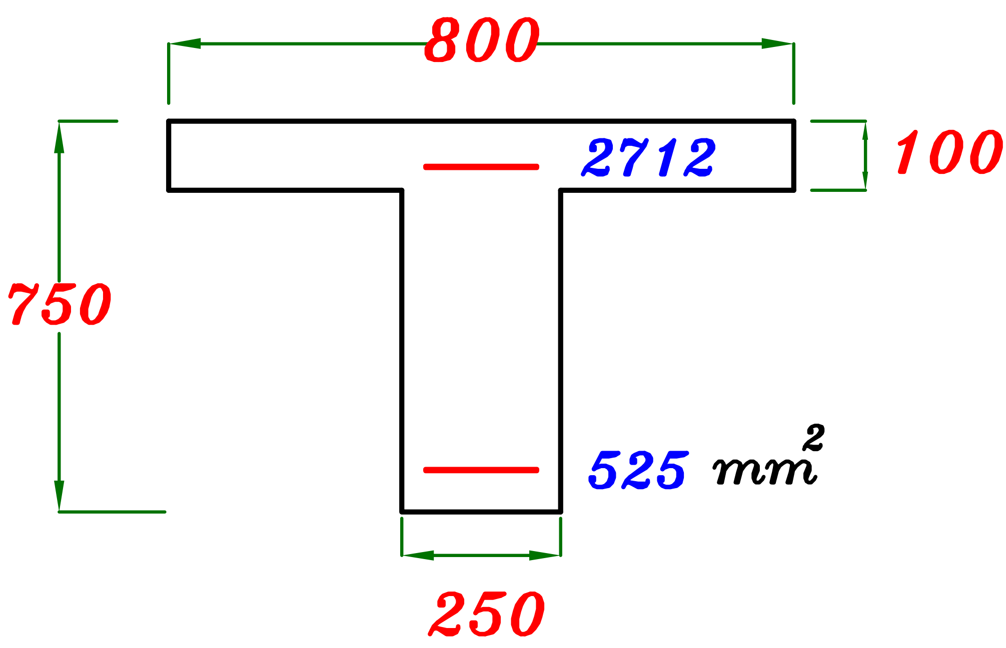
$\mu_{max.} = 5*10^{-4}*F_{cu} = 5*10^{-4}*25 = 0.0125$

$\therefore A_s = \mu_{max.}\, b\, d + A_{s`} = 0.0125(250)(700) + 525 = 2712\ mm^2$

$\therefore \boxed{A_s = 2712\ mm^2}$

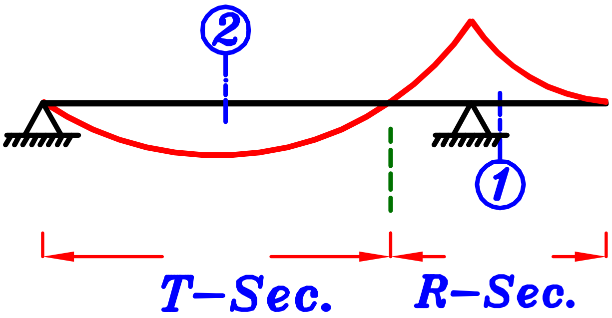
- Check $A_{s`_{max.}} = 0.4\, A_s = 0.4\,(2712) = 1084.8\ mm^2$

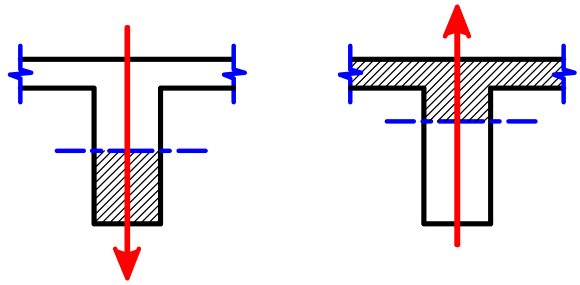
$\therefore A_{s`} < A_{s`_{max.}}$ $\therefore$ o.k.



Design of T-Section & L-Section using First Principles

* **T-Section.** (أى أن البلاطة من الإتجاهين) كمره وسطيه

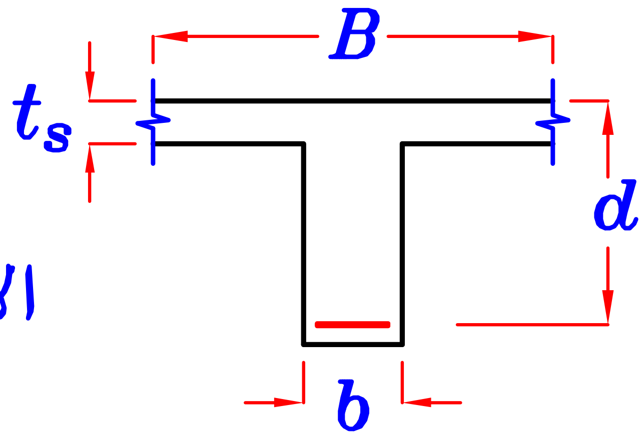




Sec. (1-1)
R-section

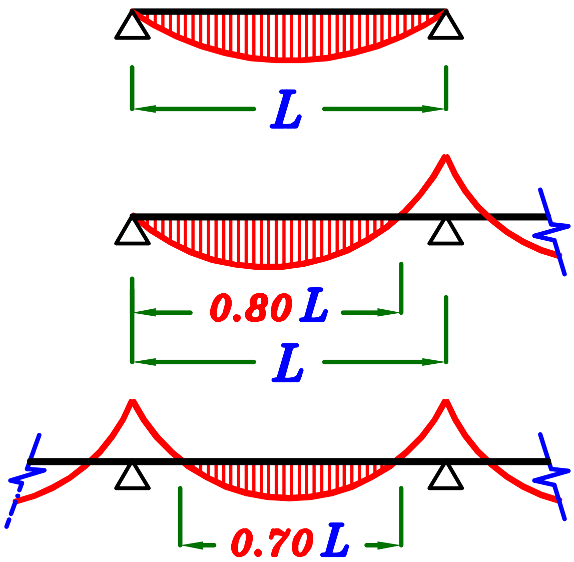
Sec. (2-2)
T-section

Effective Width. (B)



$$B = \begin{Bmatrix} \underset{slab}{C.L} \rightarrow \underset{slab}{C.L} \\ 16\,t_s + b \\ K\,\frac{L}{5} + b \end{Bmatrix} \text{الأقل}$$

بعد حساب الثلاث قيم لل B نأخذ أقل قيمه منهم لانه more safe فى التصميم ان نعتبر القطاع اضعف .



$K = 1.0$

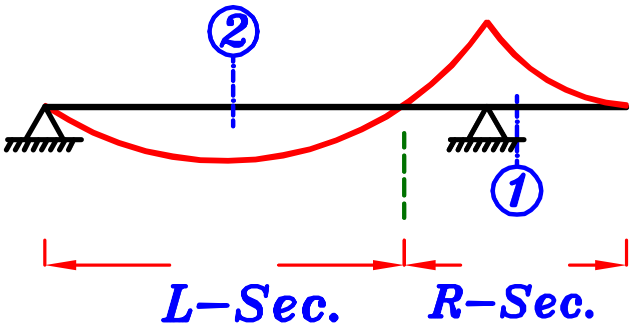
$K = 0.80$

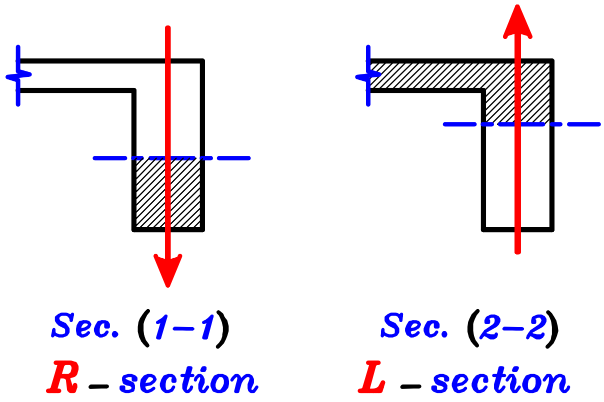
$K = 0.70$

L هو طول الكمره الحقيقى span من ال support الى ال support

K هو Factor بحيث تكون قيمه $K*L$ هو البحر المعلق للكمره أى هو طول الكمره الذى كل القطاعات فيه نوعها T-Sec.

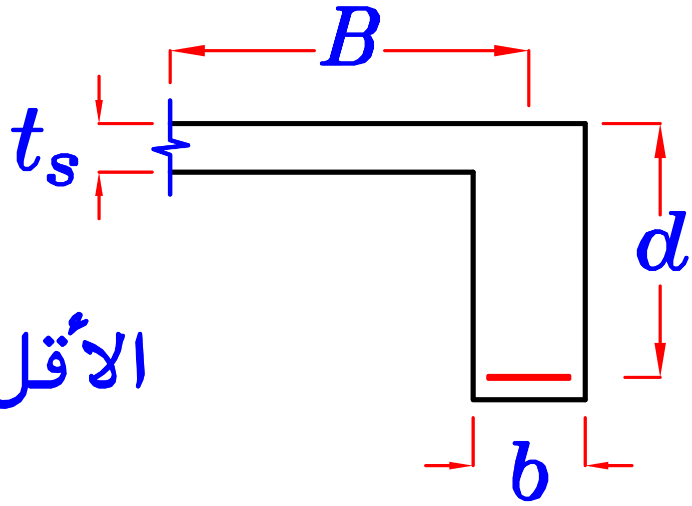
* L–Sections. (أى أن البلاطة من جهة واحده) كمره طرفية



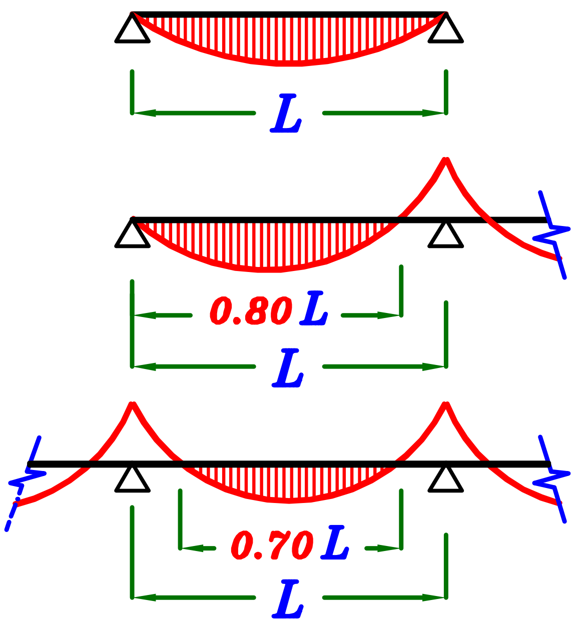


Effective Width. (B)

$$B = \left\{ \begin{array}{l} C.L_{beam} \rightarrow C.L_{slab} \\ 6\,t_s + b \\ K\,\dfrac{L}{10} + b \end{array} \right\} \text{ الأقل}$$



بعد حساب الثلاث قيم لل *B* نأخذ أقل قيمه منهم لانه *more safe* فى التصميم ان نعتبر القطاع اضعف .



$K = 1.0$

$K = 0.80$

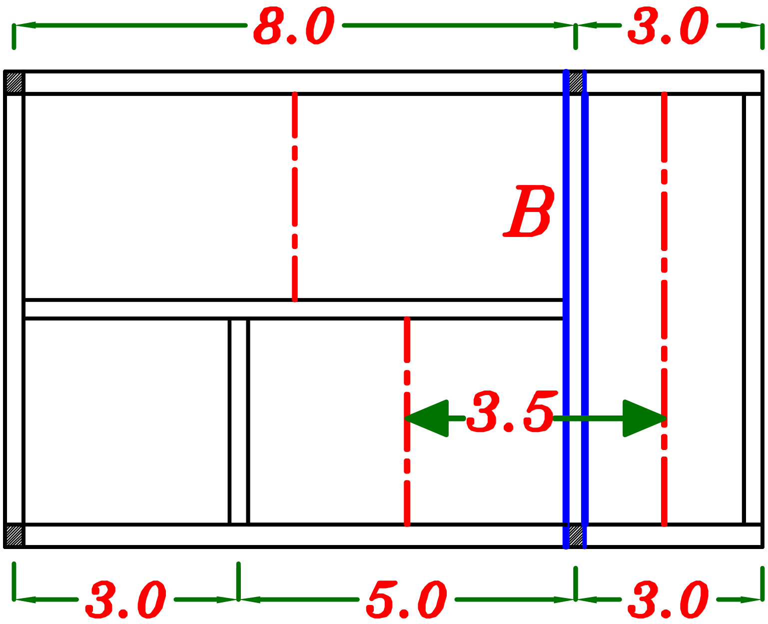
$K = 0.70$

L هو طول الكمره الحقيقى *span* من ال *support* الى ال *support*

K هو *Factor* بحيث تكون قيمه *K*L* هو البحر المعلق للكمره أى هو طول الكمره الذى كل القطاعات فيه نوعها *L–Sec.*

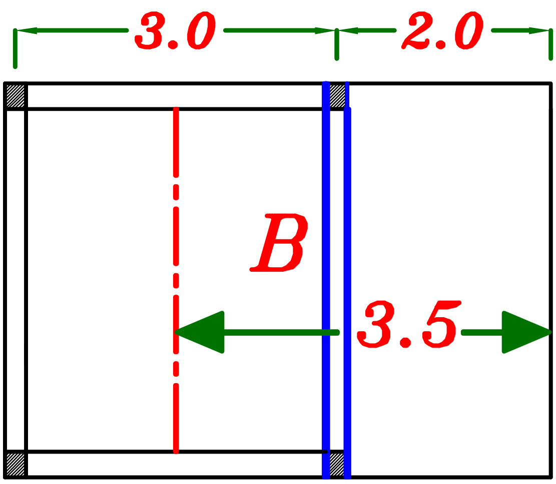
Special Cases of Calulating B

عند حساب قيمه ال B و وجدنا انه من الممكن ان تكون هناك عده قيم لل B نأخذ أقل قيمه منهم لانه more safe فى التصميم ان نعتبر القطاع اضعف .



$$\underset{slab}{C.L.}-\underset{slab}{C.L.}=\frac{3.0}{2}+\frac{5.0}{2}$$

$$=4.0\ m$$



اذا وجدت بلاطه Cantilever

عند حساب قيمه $\underset{slab}{C.L.}-\underset{slab}{C.L.}$

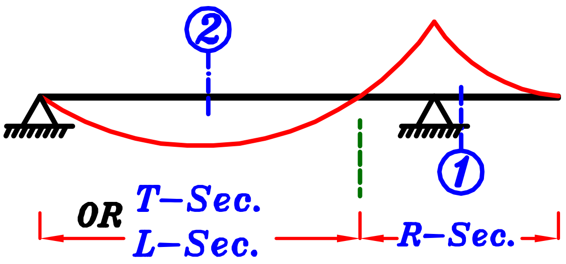
يتم أخذ طول البلاطه ال Cantilever

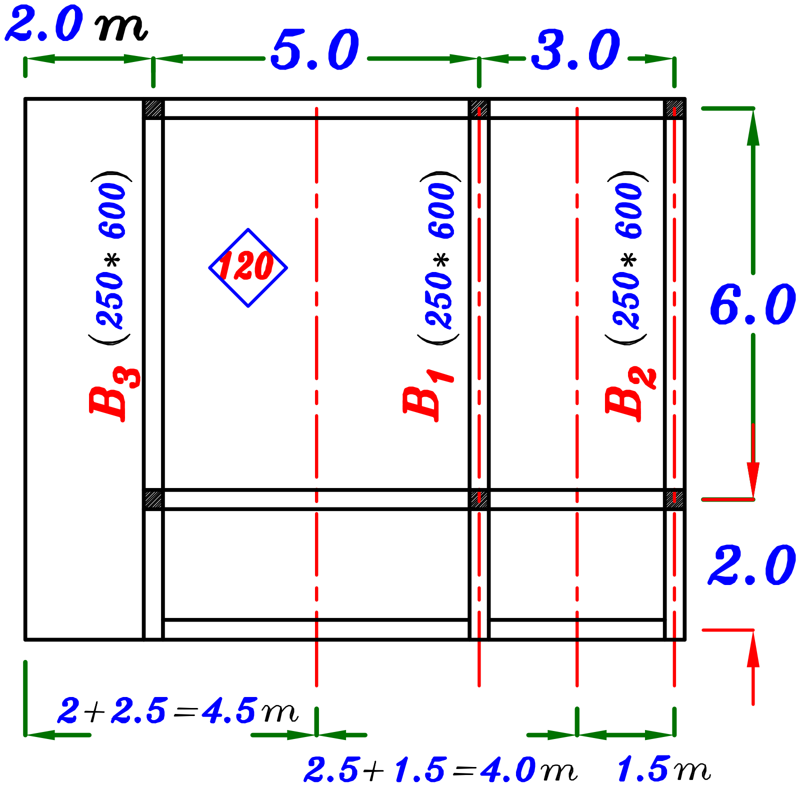
$$\underset{slab}{C.L.}-\underset{slab}{C.L.}=\frac{3.0}{2}+2.0$$

$$=3.50\ m$$

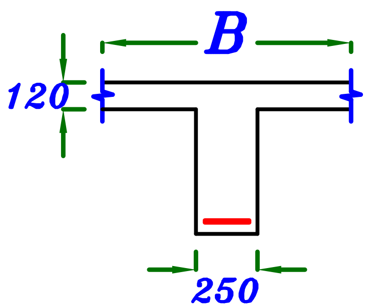
Example.

Get B For B_1 , B_2 , B_3



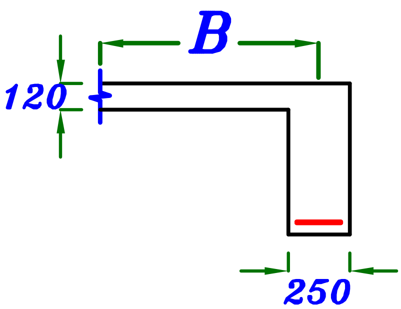


B_1 كمره وسطيه



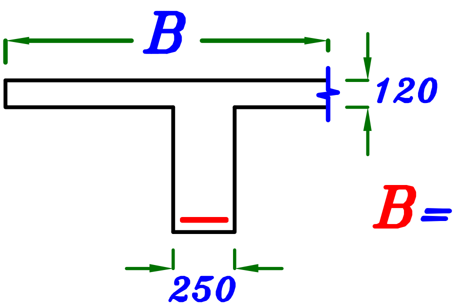
$$B = \left\{ \begin{array}{ll} C.L.-C.L. & = 2.5+1.5 = 4.0\ m = 4000\ mm \\ 16\ t_s + b & = 16 * 120 + 250 = 2170\ mm \\ K \dfrac{L}{5} + b & = 0.8 * \dfrac{6000}{5} + 250 = 1210\ mm \end{array} \right\} = 1210\ mm$$

B_2 كمره طرفيه



$$B = \left\{ \begin{array}{ll} C.L.-C.L. & = 1.5\ m = 1500\ mm \\ 6\ t_s + b & = 6 * 120 + 250 = 970\ mm \\ K \dfrac{L}{10} + b & = 0.8 * \dfrac{6000}{10} + 250 = 730\ mm \end{array} \right\} = 730\ mm$$

B_3 كمره وسطيه



$$B = \left\{ \begin{array}{ll} C.L.-C.L. & = 2.5+2.0 = 4.5\ m = 4500\ mm \\ 16\ t_s + b & = 16 * 120 + 250 = 2170\ mm \\ K \dfrac{L}{5} + b & = 0.8 * \dfrac{6000}{5} + 250 = 1210\ mm \end{array} \right\} = 1210\ mm$$

Steps of Design.

– IF d is not given , assume d or assume a

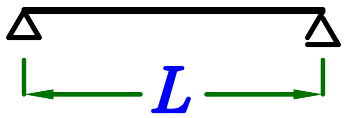
1– assume d

$d = t - 50\ mm$ IF $t \leq 1000\ mm$

$d = t - 100\ mm$ IF $t > 1000\ mm$

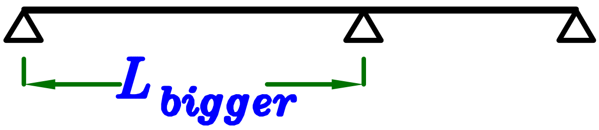
Choose t

Simple Beam



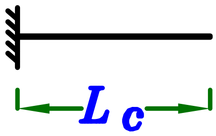
$$\boxed{t = \frac{L}{10}}$$

Continuous Beam



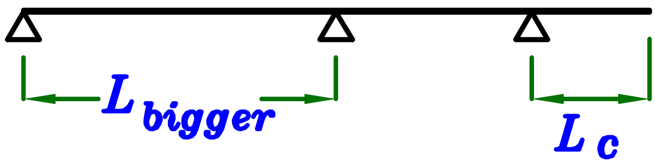
$$\boxed{t = \frac{L_{bigger}}{12}}$$

Cantilever Beam



$$\boxed{t = \frac{L_c}{5}}$$

Beam with Cantilever

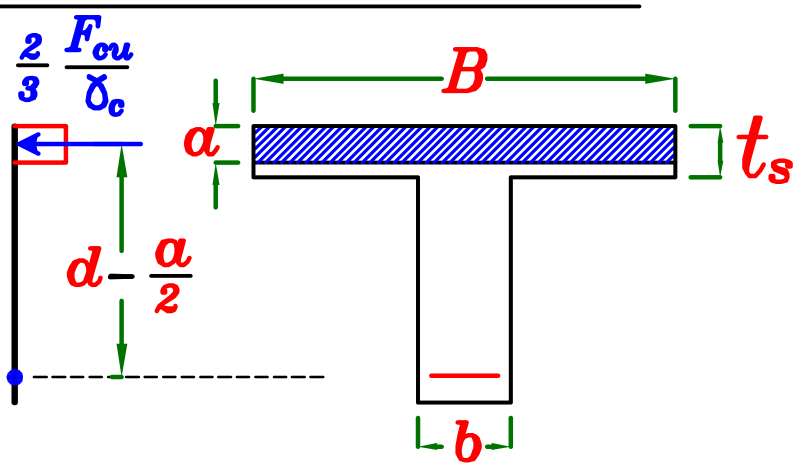


$$\boxed{\left.\begin{array}{l}\dfrac{L_{bigger}}{12} \\[2ex] \dfrac{L_c}{5}\end{array}\right\}\text{الاكبر}}$$

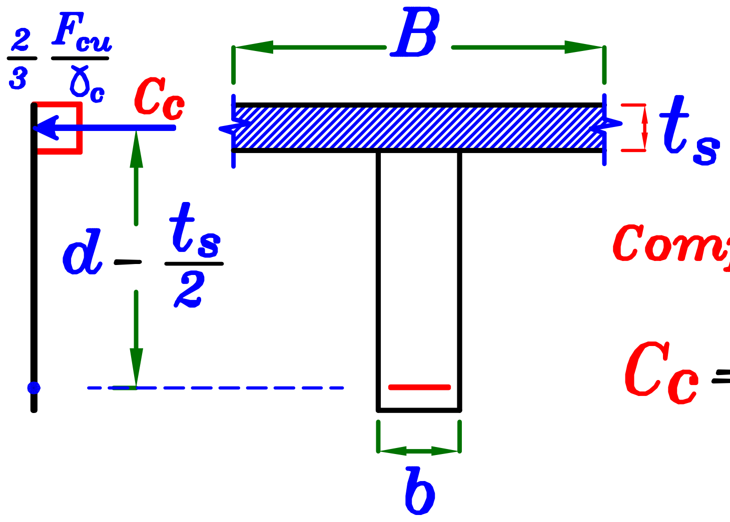
$$\boxed{t_{min.} = 400\ mm}$$

2– assume a

Take $\boxed{a = 0.9\, t_s}$



Calculate M_{Flange}



نفرض ان قيمه $a = t_s$

فتكون قيمه Compression Force

$$C_c = \frac{2}{3}\frac{F_{cu}}{\gamma_c} * (B * t_s)$$

نحسب العزم عند الحديد M_{Flange}

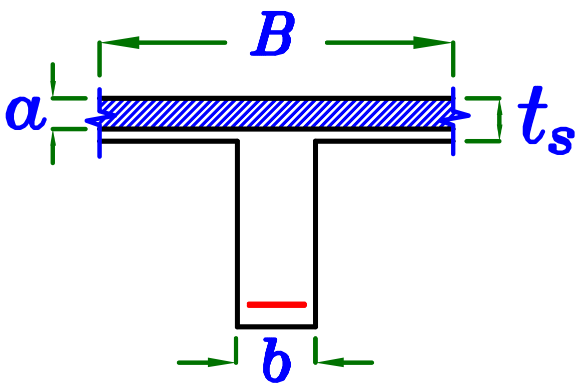
$$\boxed{M_{Flange} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, t_s\, B \left(d - \frac{t_s}{2}\right)}$$

$\boxed{M_{Flange}}$

IF $M_{U.L.} \leqslant M_{Flange}$

اذا سنحتاج لـ C_c اصغر من السابقه

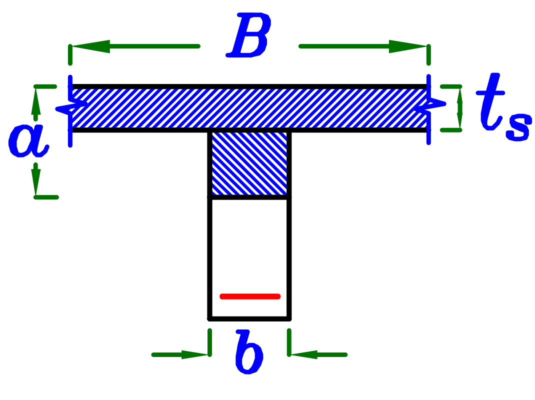
اذا $\boxed{a \leqslant t_s}$



IF $M_{U.L.} > M_{Flange}$

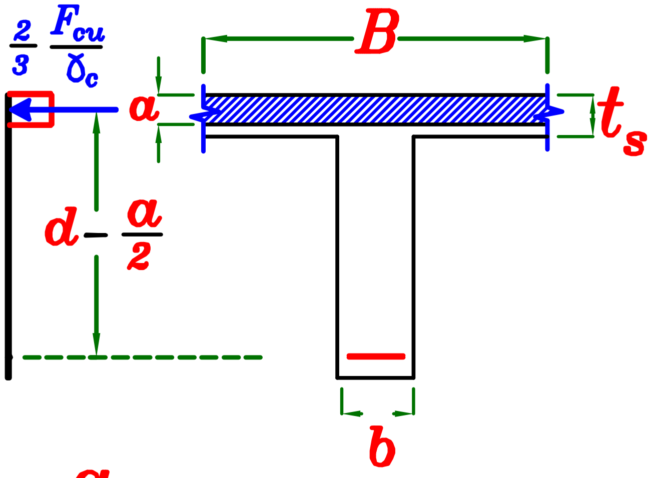
اذا سنحتاج لـ C_c اكبر من السابقه

اذا $\boxed{a > t_s}$



* IF $M_{U.L.} \leqslant M_{Flange}$

$\therefore \ a \leqslant t_s$



and the Sec. will act as R–Sec. But with width B

– Get a From.

$$M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\delta_c}\, a\, B\left(d - \frac{a}{2}\right) \xrightarrow{Get} a$$

Note that $a \leqslant t_s$

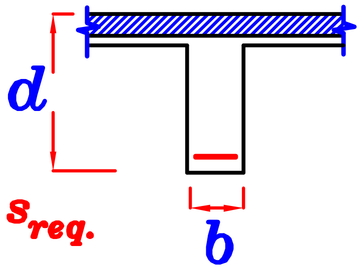
① IF $a > 0.1\,d$

– Get A_s From $\frac{2}{3}\frac{F_{cu}}{\delta_c} * a * B = A_s * \frac{F_y}{\delta_s}$

② IF $a < 0.1\,d \xrightarrow{Take} a = 0.1\,d$

– Get A_s From $M_{U.L.} = A_s \frac{F_y}{\delta_s}\left(d - \frac{0.1\,d}{2}\right)$

– Check $A_{s_{min.}}$



الصغيره

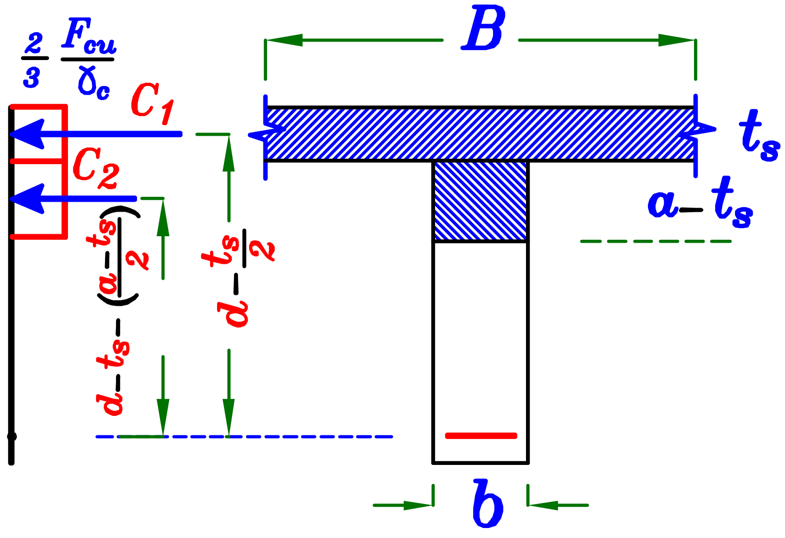
IF $A_{s_{req}} \geqslant \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\,d \xrightarrow{Take} A_s = A_{s_{req.}}$

IF $A_{s_{req}} < \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\,d \xrightarrow{Take} A_s = A_{s_{min.}}$

$$A_{s_{min.}} = \left.\begin{array}{l} \left.\begin{array}{l}\left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\,d \\ 1.3\, A_{s\,req.}\end{array}\right\} \text{الأقل} \\ \begin{array}{ll} \text{st. } 360/520 & \frac{0.15}{100}\, b\,d \\ \text{st. } 400/600 & \end{array} \end{array}\right\} \text{الأكبر}$$

$* \text{ IF } M_{U.L.} > M_{Flange}$ حالة نادره

$\therefore a > t_s$



$$C_1 = \frac{2}{3}\frac{F_{cu}}{\gamma_c} * t_s * B$$

$$C_2 = \frac{2}{3}\frac{F_{cu}}{\gamma_c}(a-t_s) * b$$

Get a From taking the moment about Tension Steel.

$$M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\gamma_c} t_s B\left(d-\frac{t_s}{2}\right) + \frac{2}{3}\frac{F_{cu}}{\gamma_c}(a-t_s)\, b\left[d-t_s-\left(\frac{a-t_s}{2}\right)\right]$$

Note that $a > t_s$

– Get $a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600+(F_y \backslash \gamma_s)}\right] * d$

① IF $a < a_{max.}$ $\xrightarrow{Get}$ A_s From

$$\frac{2}{3}\frac{F_{cu}}{\gamma_c} t_s B + \frac{2}{3}\frac{F_{cu}}{\gamma_c}(a-t_s)\, b = A_s \frac{F_y}{\gamma_s}$$

② IF $a > a_{max.}$

Note: Don't you ever use A_s` with T–sec. & L–sec.

$\therefore$ We have to increase d $\xrightarrow{Get}$ d_{new} From

Take $a = a_{max.} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600+(F_y \backslash \gamma_s)}\right] * d_{new} = X\, d_{new}$

$$\because M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\gamma_c} t_s B\left(d_{new}-\frac{t_s}{2}\right) + \frac{2}{3}\frac{F_{cu}}{\gamma_c}(a_{max.}-t_s)\, b\left[d_{new}-t_s-\left(\frac{a_{max.}-t_s}{2}\right)\right]$$

$$\therefore M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\gamma_c} t_s B\left(d_{new}-\frac{t_s}{2}\right) + \frac{2}{3}\frac{F_{cu}}{\gamma_c}(X d_{new}-t_s)\, b\left[d_{new}-t_s-\left(\frac{X d_{new}-t_s}{2}\right)\right]$$

$\therefore$ Get $d_{new} \longrightarrow$ Get $a_{max.} = X\, d_{new}$

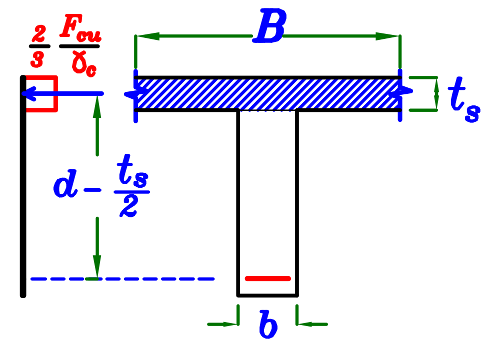
– Get A_s From

$$\frac{2}{3}\frac{F_{cu}}{\gamma_c} t_s B + \frac{2}{3}\frac{F_{cu}}{\gamma_c}(a_{max.}-t_s)\, b = A_s \frac{F_y}{\gamma_s}$$

1 – IF d is given.

Design of T–sec. & L–sec. subjected to B.M. only

Get $M_{Flange} = \frac{2}{3} \frac{F_{cu}}{\gamma_c} t_s B \left(d - \frac{t_s}{2}\right)$



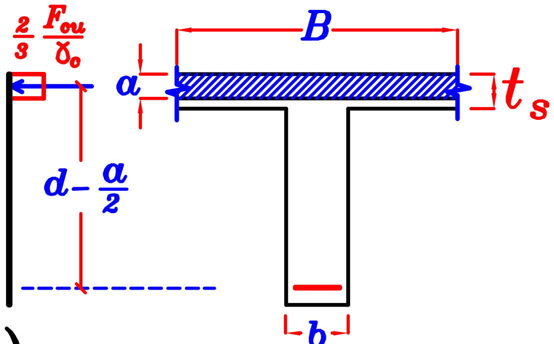
$\boxed{M_{Flange}}$

IF $M_{U.L.} \leqslant M_{Flange}$

$\therefore \; a < t_s$

$\therefore$ From

$$M_{U.L.} = \frac{2}{3} \frac{F_{cu}}{\gamma_c} a B \left(d - \frac{a}{2}\right)$$



Get $\boxed{a}$

IF $a < 0.1\,d$

$\therefore$ Take $a = 0.1\,d$

– Get A_s From

$$M_{U.L.} = A_s \frac{F_y}{\gamma_s} \left(d - \frac{0.1\,d}{2}\right)$$

IF $a > 0.1\,d$

Get A_s

From $\frac{2}{3} \frac{F_{cu}}{\gamma_c} * a * B = A_s * \frac{F_y}{\gamma_s}$

Check $A_{s_{min.}} = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\,d$ الصغيره

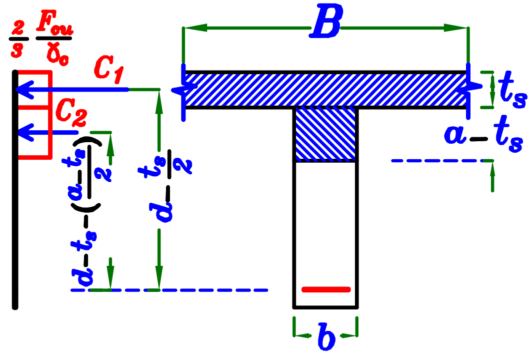
IF $M_{U.L.} > M_{Flange}$

حاله نادره

$\therefore \; a > t_s$

$\therefore$ Get a From

$$M_{U.L.} = \frac{2}{3} \frac{F_{cu}}{\gamma_c} t_s B \left(d - \frac{t_s}{2}\right) + \frac{2}{3} \frac{F_{cu}}{\gamma_c} (a - t_s)\, b \left[d - t_s - \left(\frac{a - t_s}{2}\right)\right]$$



Get A_s From $\frac{2}{3} \frac{F_{cu}}{\gamma_c} t_s B + \frac{2}{3} \frac{F_{cu}}{\gamma_c} (a - t_s)\, b = A_s \frac{F_y}{\gamma_s}$

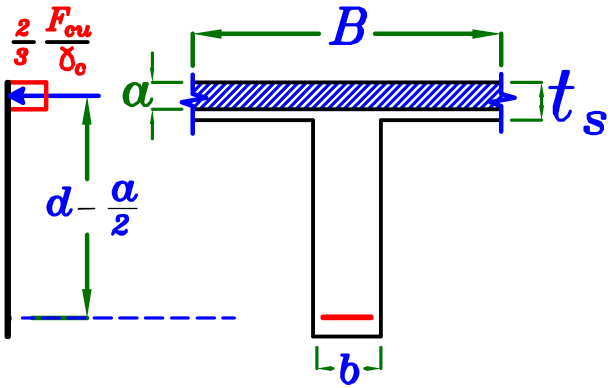
ملحوظه هذه الحاله نادره
و ممكن اهمالها فى التصميم
و أخذ $a = t_s$

2 – IF d is not given.

$a \leqslant t_s$

Design of T–sec. & L–sec. subjected to B.M. only

Get B For the Sec.
assume d or a



IF d is assumed

$\therefore$ From

$$M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, a\, B \left(d - \frac{a}{2}\right)$$

Get $\boxed{a}$

IF $a \leqslant 0.1\, d$

$\therefore$ Take $a = 0.1\, d$

– Get A_s From

$$M_{U.L.} = A_s \frac{F_y}{\gamma_s}\left(d - \frac{0.1\, d}{2}\right)$$

IF $a > 0.1\, d$

Get A_s

From $\frac{2}{3}\frac{F_{cu}}{\gamma_c} * a * B = A_s * \frac{F_y}{\gamma_s}$

Check $A_{s_{min.}} = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d$ الصغيره

IF a is assumed $a \simeq (0.8 \rightarrow 1.0)\ t_s$

From

$$M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, a\, B \left(d - \frac{a}{2}\right)$$

Get $\boxed{a}$

IF $a \leqslant 0.1\, d$

$\therefore$ Take $a = 0.1\, d$

– Get A_s From

$$M_{U.L.} = A_s \frac{F_y}{\gamma_s}\left(d - \frac{0.1\, d}{2}\right)$$

IF $a > 0.1\, d$

Get A_s

From $\frac{2}{3}\frac{F_{cu}}{\gamma_c} * a * B = A_s * \frac{F_y}{\gamma_s}$

Check $A_{s_{min.}} = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d$ الصغيره

Example.

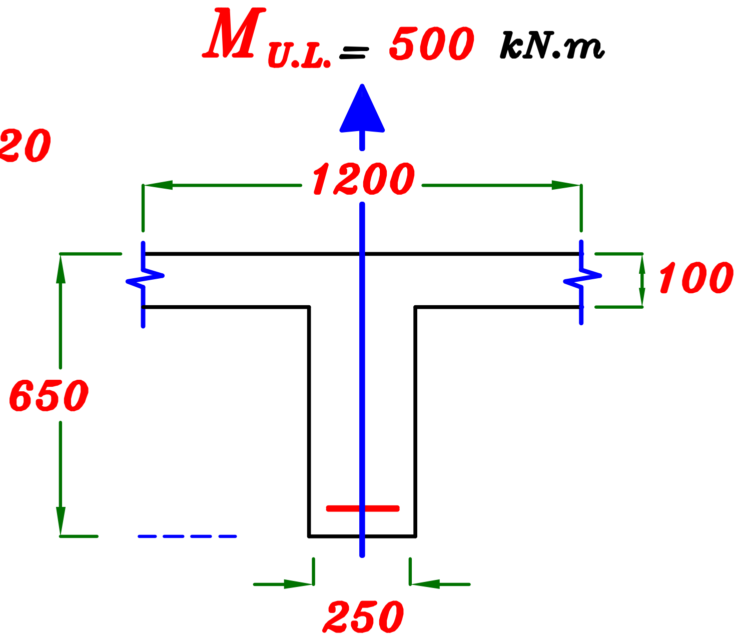
$F_{cu} = 25\ N\backslash mm^2$, **st.** 360/520

$b = 250\ mm$

$B = 1200\ m$

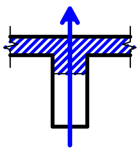
$d = 600\ m$

$M_{U.L.} = 500\ kN.m$



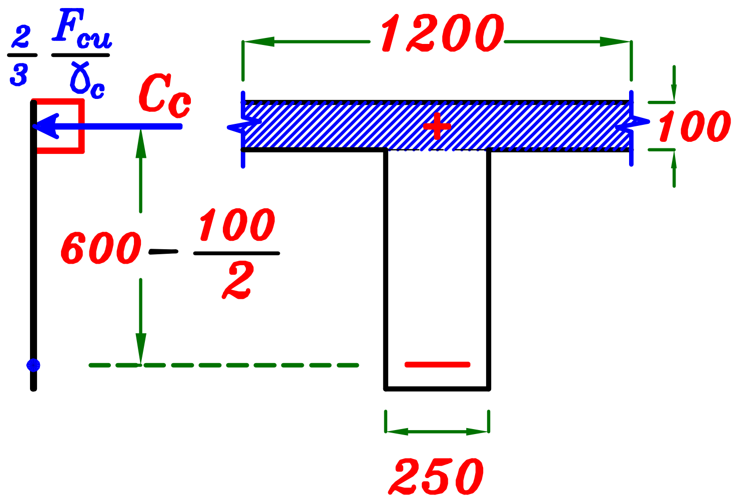
Get A_s

Solution.

T-Sec. 

$a_{min} = 0.10\,d = 0.10 * 600 = 60\ mm$

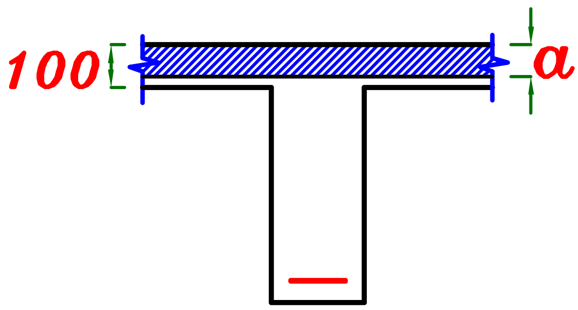
$a_{max} = 0.35\,d = 0.35 * 600 = 210\ mm$

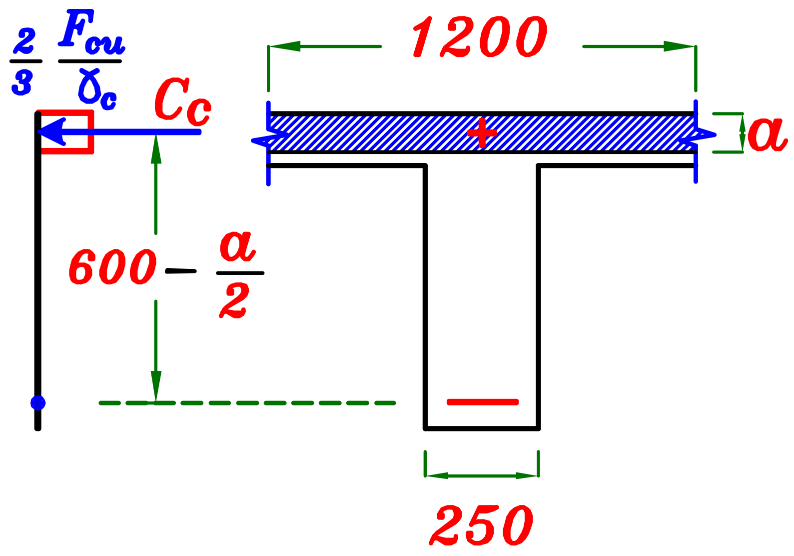


$$M_{Flange} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\,t_s\,B\left(d - \frac{t_s}{2}\right) = \frac{2}{3}\left(\frac{25}{1.5}\right)(100)(1200)\left(600 - \frac{100}{2}\right)$$

$$= 733333333\ N.mm = 733.33\ kN.m$$

$$\therefore M_{U.L.} < M_{Flange} \longrightarrow a < t_s$$





- Get a From $M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, a\, B \left(d - \frac{a}{2}\right)$

$\therefore\ 500*10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(a)(1200)\left(600 - \frac{a}{2}\right)$

$\therefore\ \boxed{a = 66.14\ mm} \qquad \therefore\ a_{min} < a < a_{max} \qquad \therefore\ o.k.$

$\therefore\ a > 0.1\ d \xrightarrow{Get} A_s \xrightarrow{From} \frac{2}{3}\frac{F_{cu}}{\gamma_c} * a * B = A_s * \frac{F_y}{\gamma_s}$

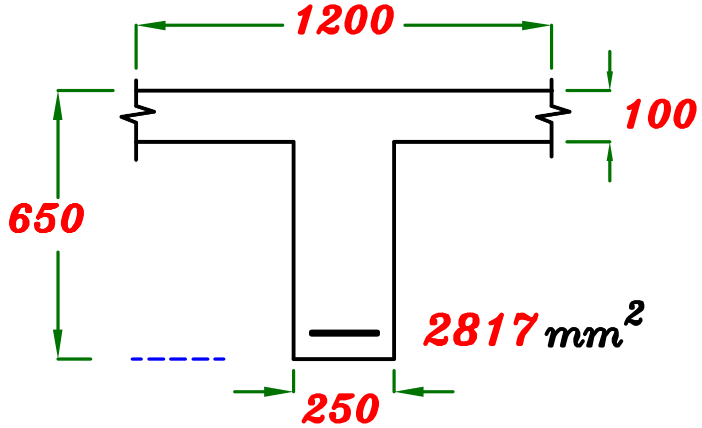
$\frac{2}{3}\left(\frac{25}{1.5}\right)(66.14)(1200) = A_s \left(\frac{360}{1.15}\right) \longrightarrow A_{s_{req.}} = 2817\ mm^2$

<u>Check $A_{s_{min.}}$</u> $\quad \because\ F_{cu} = 25\ N\backslash mm^2$

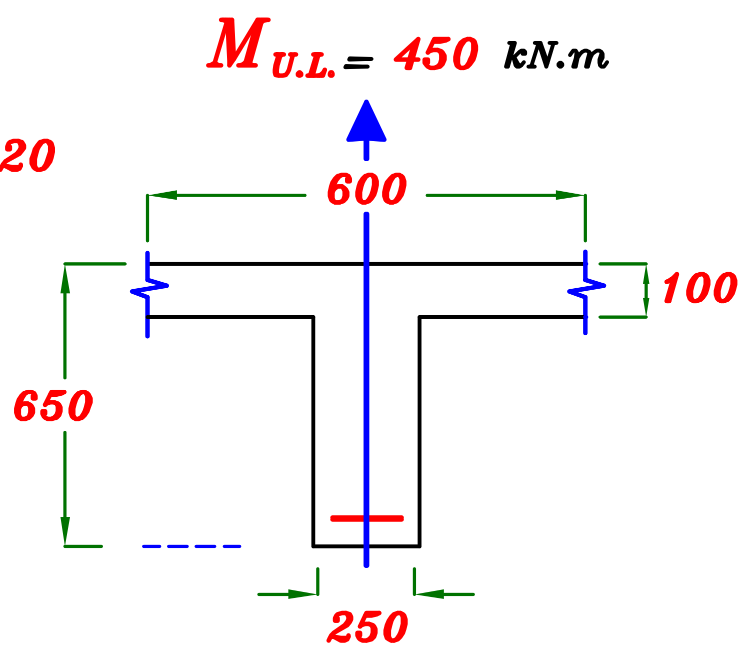
الصغيره

$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 600 = 468.7\ mm^2$

$\therefore\ A_{s_{req.}} > \mu_{min.}\, b\, d \qquad \therefore$ Take $A_s = A_{s_{req.}} = 2817\ mm^2$



Example.



$F_{cu} = 25\ N\backslash mm^2$, st. 360/520

$b = 250$ mm

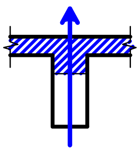
$B = 1200$ m

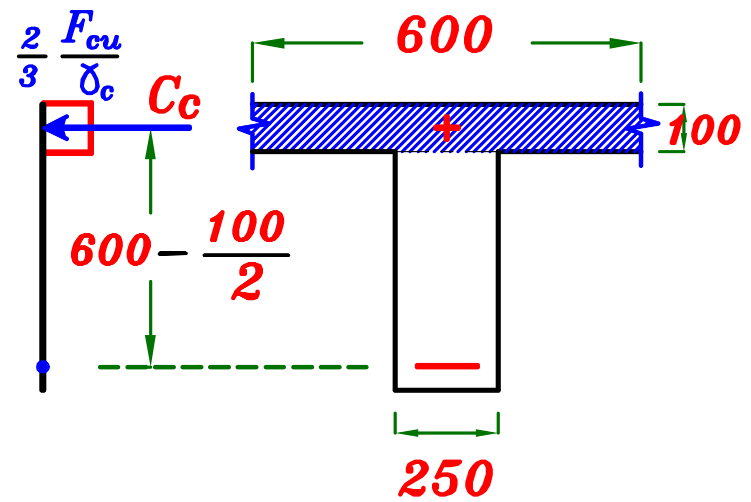
$d = 600$ m

$M_{U.L.} = 450$ kN.m

Get A_s

Solution.

T–Sec. 



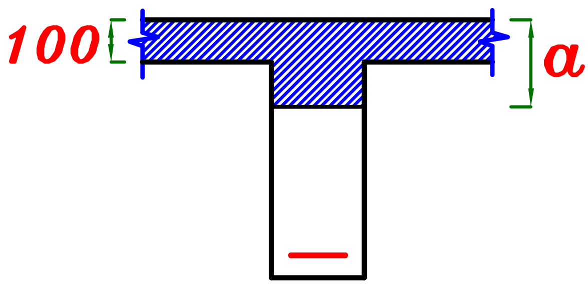
$$a_{min} = 0.10\,d = 0.10 * 600 = 60 \text{ mm}$$

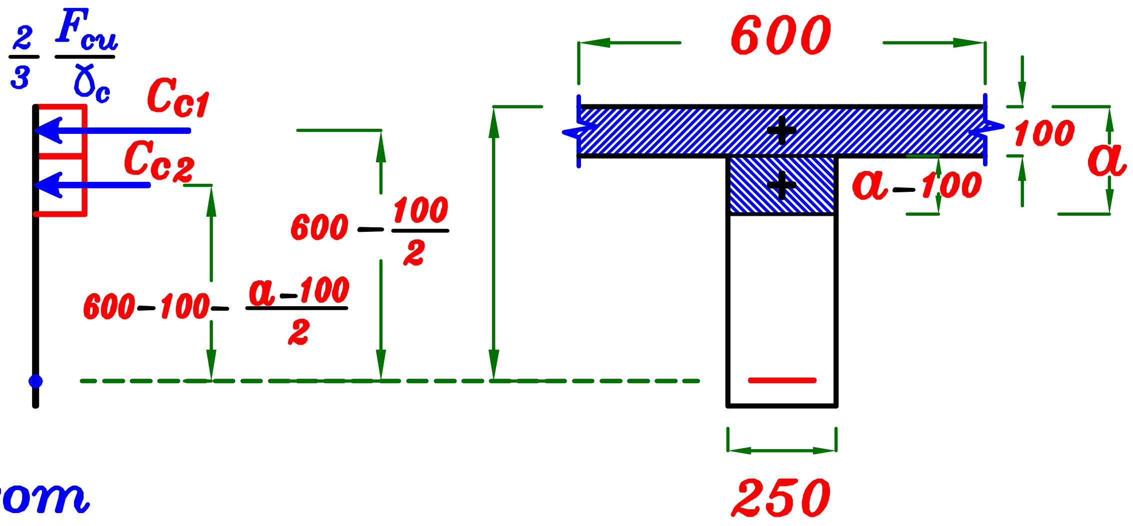
$$a_{max} = 0.35\,d = 0.35 * 600 = 210 \text{ mm}$$

$$M_{Flange} = \frac{2}{3}\frac{F_{cu}}{\gamma_c} t_s B \left(d - \frac{t_s}{2}\right) = \frac{2}{3}\left(\frac{25}{1.5}\right)(100)(600)\left(600 - \frac{100}{2}\right)$$

$$= 366666666 \text{ N.mm} = 366.67 \text{ kN.m}$$

$$\therefore M_{U.L.} > M_{Flange} \longrightarrow a > t_s$$





Get a From

$$M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, t_s\, B \left(d - \frac{t_s}{2}\right) + \frac{2}{3}\frac{F_{cu}}{\gamma_c}(a - t_s)\, b \left[d - t_s - \left(\frac{a - t_s}{2}\right)\right]$$

$$450 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(100)(600)\left(600 - \frac{100}{2}\right) + \frac{2}{3}\left(\frac{25}{1.5}\right)(a - 100)(250)\left[600 - 100 - \left(\frac{a - 100}{2}\right)\right]$$

$\therefore \boxed{a = 164.11 \text{ mm}}$ $\quad \therefore a_{min} < a < a_{max} \quad \therefore$ o.k.

Get A_s From $\quad \frac{2}{3}\frac{F_{cu}}{\gamma_c} t_s B + \frac{2}{3}\frac{F_{cu}}{\gamma_c}(a - t_s)\, b = A_s \frac{F_y}{\gamma_s}$

$$\therefore \frac{2}{3}\left(\frac{25}{1.5}\right)(100)(600) + \frac{2}{3}\left(\frac{25}{1.5}\right)(164.11 - 100)(250) = A_s \left(\frac{360}{1.15}\right)$$

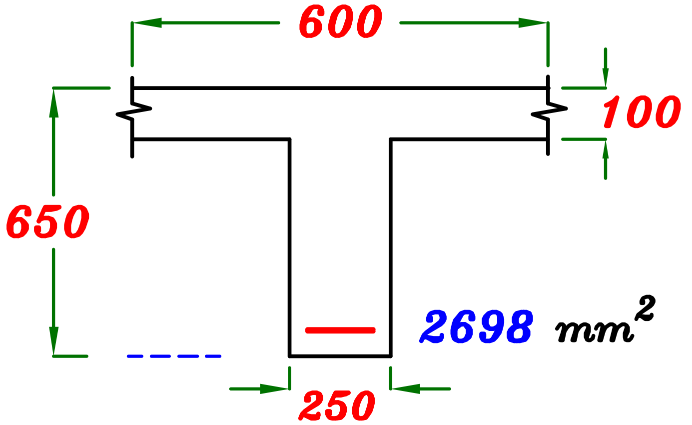
$\therefore \boxed{A_s = 2698 \text{ mm}^2}$

Check $A_{s\,min.}$ $\quad \because F_{cu} = 25 \text{ N}\backslash\text{mm}^2$

الصغيره

$$\therefore \mu_{min.} = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 250 * 600 = 468.7 \text{ mm}^2$$

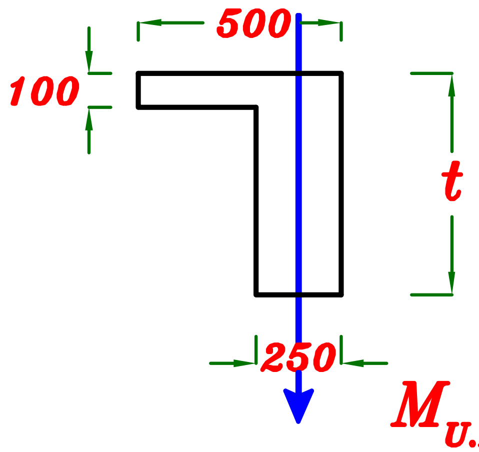
$\therefore A_{s_{req.}} > \mu_{min.}\, b\, d \quad \therefore$ Take $A_s = A_{s_{req.}} = 2698 \text{ mm}^2$



Example.

$F_{cu} = 25 \ N\backslash mm^2$

st. 360/520



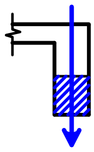
$M_{U.L.} = 350$ kN.m

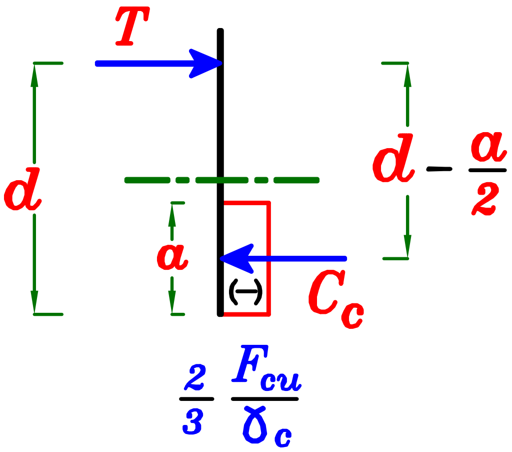
Req.

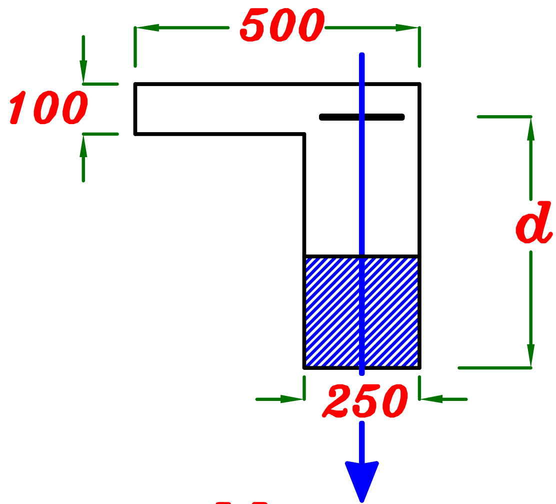
Using First Principles Design the Sec. For Bending With min. Depth. & without $A_{s`}$

Solution.

R–Sec.







$M_{U.L.} = 350$ kN.m

To get $d_{min.} \xrightarrow{use} a = a_{max.}$, $A_s = A_{s\,max.}$

$$a_{max.} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \gamma_s)}\right] * d = 0.35\ d$$

$$\mu_{max.} = 5 * 10^{-4} * F_{cu} = 5 * 10^{-4}(25) = 0.0125$$

$$A_{s_{max.}} = \mu_{max.}\, b\, d = 0.0125\,(250)\, d = 3.125\ d$$

From $M_{U.L._{max.}} = \frac{2}{3} \frac{F_{cu}}{\gamma_c} a_{max.} b \left(d_{min} - \frac{a_{max.}}{2}\right)$

$$\therefore 350 * 10^6 = \frac{2}{3} \left(\frac{25}{1.5}\right) (0.35\, d_{min}) (250) \left(d_{min} - \frac{0.35\, d_{min}}{2}\right)$$

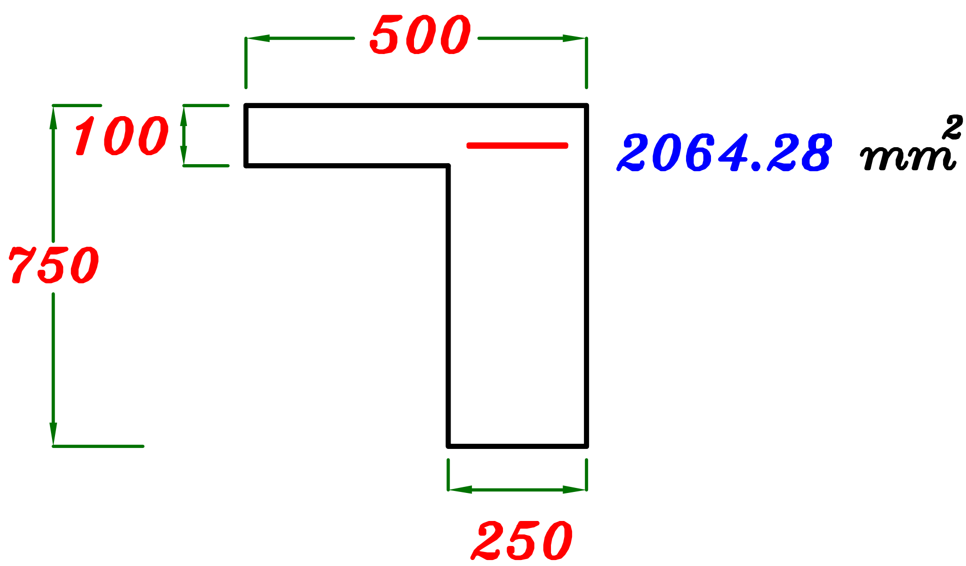
$$\therefore d_{min.} = 660.57\ mm$$

$\therefore$ Take $\boxed{d = 700\ mm}$, $\boxed{t = 750\ mm}$

– Get A_s From

$$A_{s_{max.}} = 3.125\ d = 3.125\ (660.57) = 2064.28\ mm^2$$

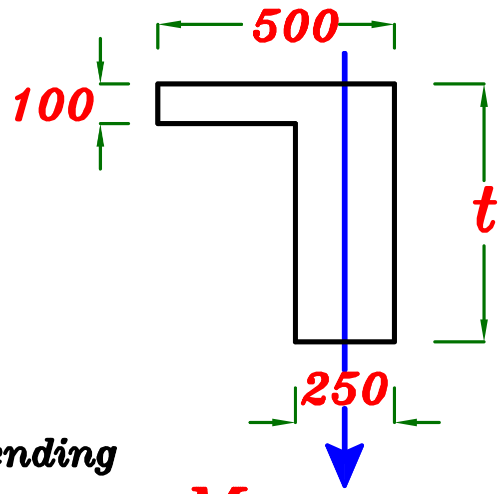
$$\boxed{A_s = A_{s_{max.}} = 2064.28\ mm^2}$$



Example.

$F_{cu} = 25 \; N\backslash mm^2$

st. 360/520



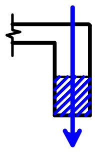
$M_{U.L.} = 350 \; kN.m$

Req.

Using First Principles Design the Sec. For Bending

With min. Depth. & with $A_{s`}$

Solution.

R-Sec. 

To get $d_{min.}$ $\xrightarrow{\text{Take}}$ $a = a_{max.}$

$$, \quad A_s = A_{s_{max.}} + A_{s`} \qquad , \quad A_{s`} = A_{s`_{max.}}$$

$$A_{s`_{max.}} = 0.4 \, A_s = 0.4 \left( A_{s_{max.}} + A_{s`_{max.}} \right)$$

$$\therefore \; A_{s`_{max.}} = 0.4 \left( \mu_{max.} b \, d + A_{s`_{max.}} \right)$$

$$\therefore \; A_{s`_{max.}} = 0.4 \, \mu_{max.} b \, d + 0.4 \, A_{s`_{max.}}$$

$$\therefore \; 0.6 \, A_{s`_{max.}} = 0.4 \, \mu_{max.} b \, d$$

$$\therefore \; \boxed{A_{s`_{max.}} = \frac{2}{3} \mu_{max.} b \, d}$$

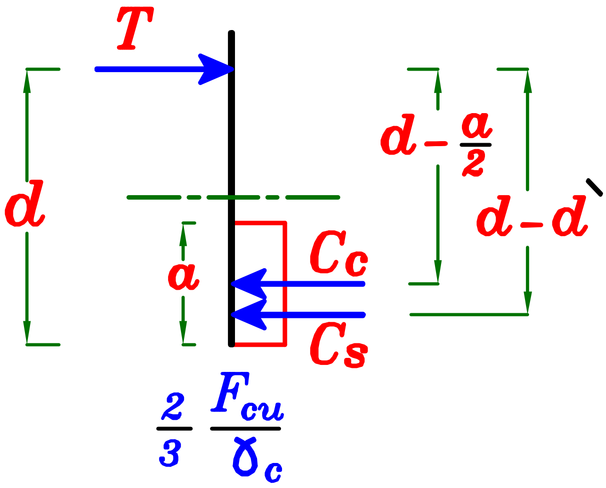
أكتب هذا الاثبات قبل حل المسأله

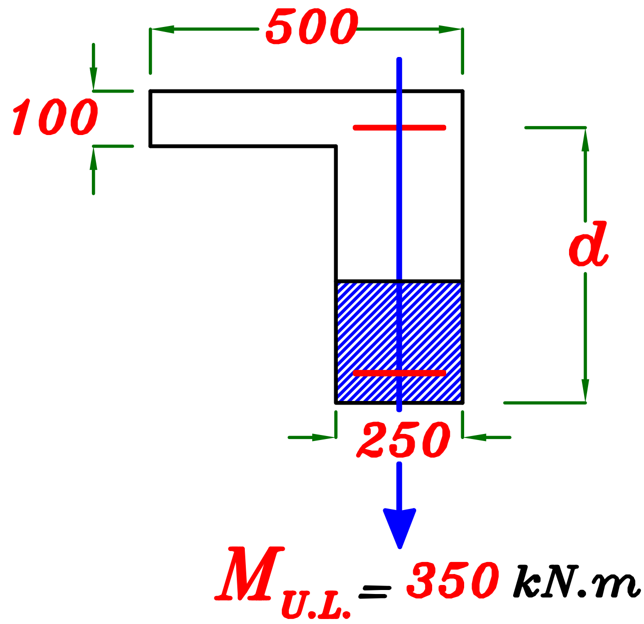
$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \gamma_s)}\right] * d = 0.35\, d$$

$$\mu_{max.} = 5 * 10^{-4} * F_{cu} = 5 * 10^{-4}\,(25) = 0.0125$$

$$A_{s_{max.}} = \mu_{max.}\, b\, d = 0.0125\,(250)\, d = 3.125\, d$$

$$A_{s`_{max.}} = \frac{2}{3}\, \mu_{max.}\, b\, d = \frac{2}{3}\,(0.0125)\,(250)\, d = 2.08\, d$$





From $M_{U.L._{max.}} = \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\, a_{max.}\, b\left(d - \frac{a_{max.}}{2}\right) + A_{s`_{max.}}\,\frac{F_y}{\gamma_s}\,(d - d`)$

$$\therefore 350 * 10^{6} = \frac{2}{3}\left(\frac{25}{1.5}\right)(0.35\, d)\,(250)\left(d - \frac{0.35\, d}{2}\right) + (2.08 d)\left(\frac{360}{1.15}\right)(d - 50)$$

$\therefore d = 502.09$ mm $\xrightarrow{\text{Take}}$ $\boxed{d = 550 \text{ mm}}$, $\boxed{t = 600 \text{ mm}}$

- Get A_s From

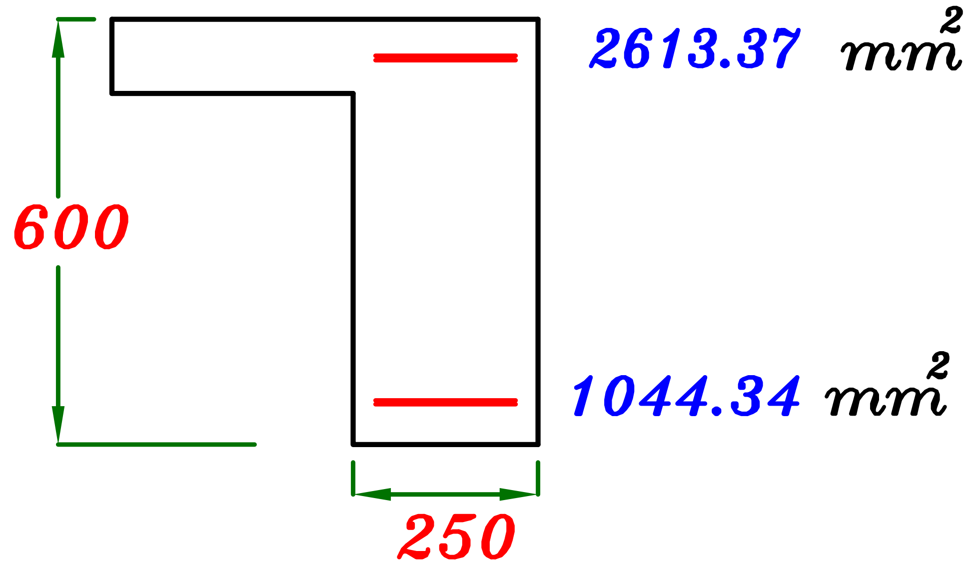
$$A_{s_{max.}} = 3.125\ d = 3.125\ (502.09) = 1569.03\ mm^2$$

$$A_{s`_{max.}} = 2.08\ d = 2.08\ (502.09) = 1044.34\ mm^2$$

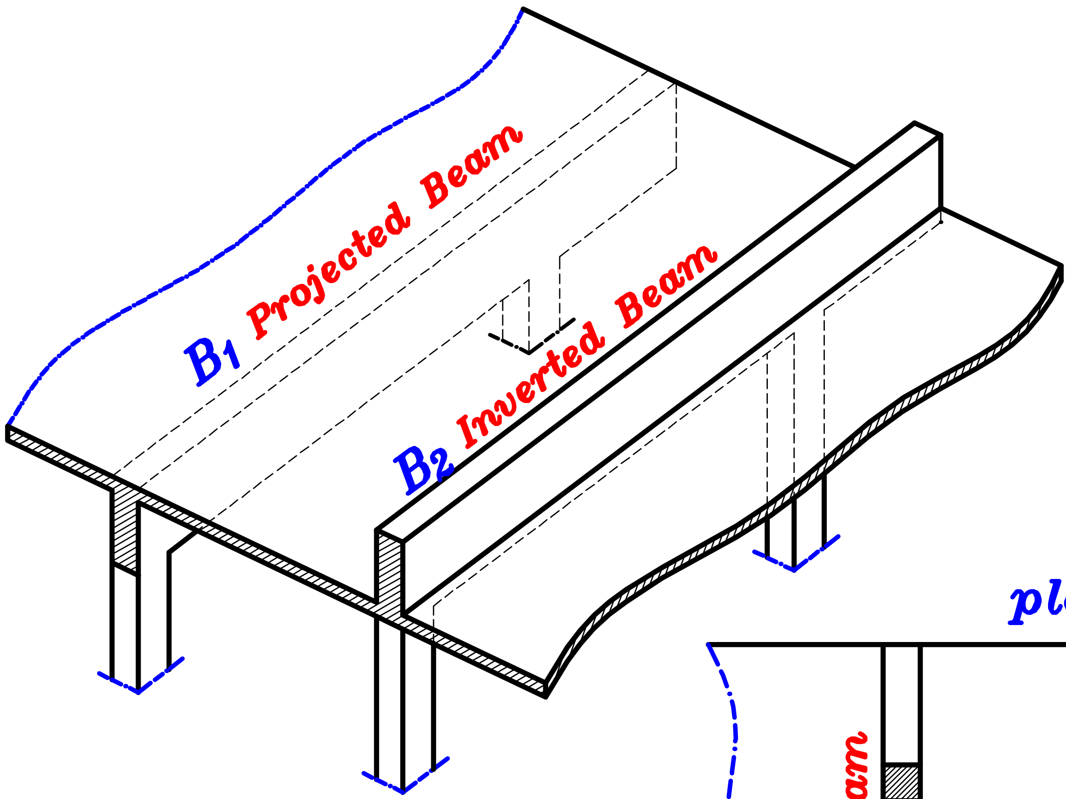
$$\boxed{A_{s`} = A_{s`_{max.}} = 1044.34\ mm^2}$$

$$A_s = A_{s_{max.}} + A_{s`_{max.}} = 1569.03 + 1044.34 = 2613.37\ mm^2$$

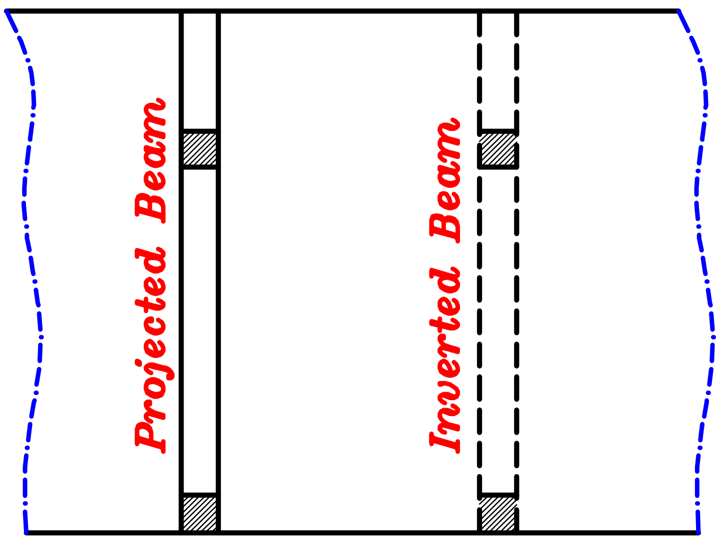
$$\boxed{A_s = 2613.37\ mm^2}$$



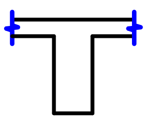
Projected & Inverted Beams.



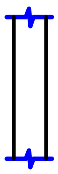
plan



Projected Beams الكمرات الساقطه

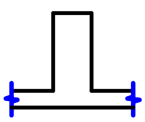


و هى كمرات يكون منسوب البلاطه فوق الكمره حيث يكون شكل قطاع الكمره

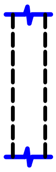


و يكون وزن البلاطه هو الذى يُحمل على الكمره ، و يرسم شكل الكمره فى ال plan

Inverted Beams الكمرات المقلوبه

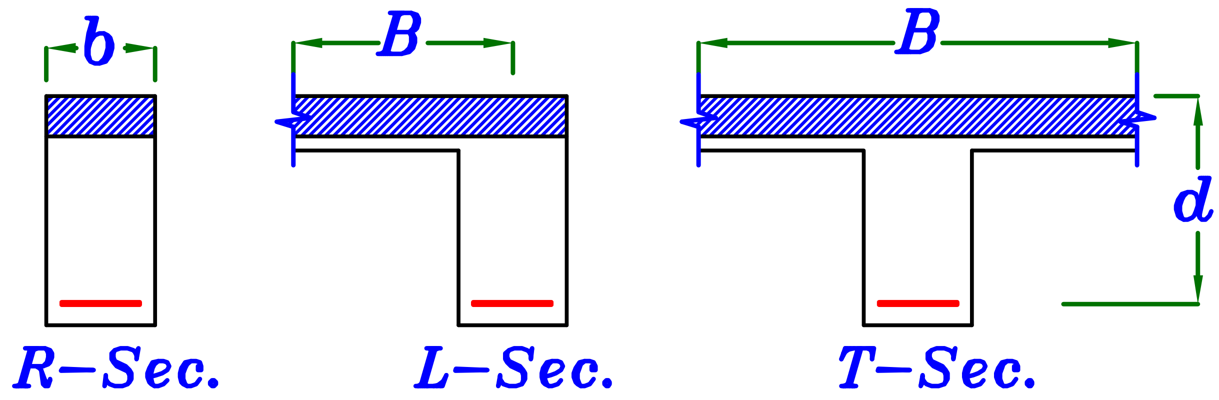


و هى كمرات يكون منسوب البلاطه أسفل الكمره حيث يكون شكل قطاع الكمره



و يكون وزن البلاطه هو الذى يُحمل على الكمره ، و يرسم شكل الكمره فى ال plan

ترتيب تصميم القطاعات . Design Order.



يتم تصميم القطاعات T-Sec. & L-Sec. & R-Sec. على أنها R-Sec. و لكن بعرض مختلف.

لان عرض ال B للقطاع ال T-Sec. أكبر من L-Sec. أكبر من R-Sec.

اذا القطاع ال T-Sec. أقوى من L-Sec. أقوى من R-Sec.

اذا عند التصميم سيحتاج القطاع ال R-Sec. لعمق اكبر من ال L-Sec. اكبر من ال T-Sec.

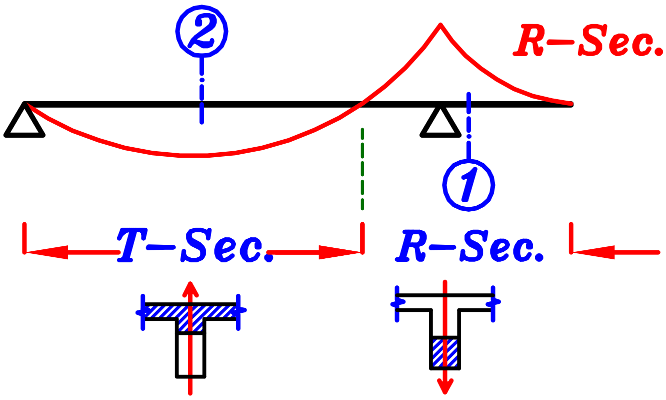
لذا اذا كانت الكمره الواحده يوجد بها مثلا T-Sec. و R-Sec.

سنبدأ بتصميم ال R-Sec. أولا و نوجد له A_s , d

ثم نأخذ قيمه ال d لل R-Sec. على كل الكمره

ثم نصمم ال T-Sec. بنفس ال d لل R-Sec.

و نوجد له A_s فقط.



إذا كان فى الكمره قطاعان T-Sec. & R-Sec. نبدأ بتصمم ال R-Sec. أولاً.

إذا كان فى الكمره قطاعان L-Sec. & R-Sec. نبدأ بتصمم ال R-Sec. أولاً.

إذا كان فى الكمره قطاعان T-Sec. & L-Sec. نبدأ بتصمم ال L-Sec. أولاً.

إذا كان كل قطاعات الكمره من نفس النوع فنبدأ بتصميم القطاع الذى يؤثر عليه moment أولاً.

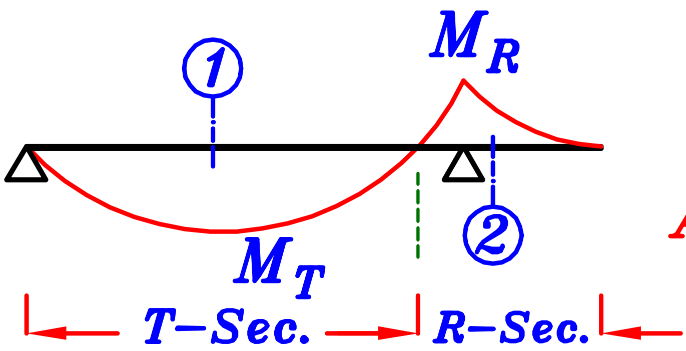
الحاله الوحيده التى نبدأ فيها التصميم لل T-Sec.

قبل ال R-Sec. عندما يكون $\boxed{M_T > 2\,M_R}$

فنعمل على فرض ال d لل T-Sec. و نوجد له A_s

ثم نصمم ال R-Sec. بنفس ال d لل T-Sec.

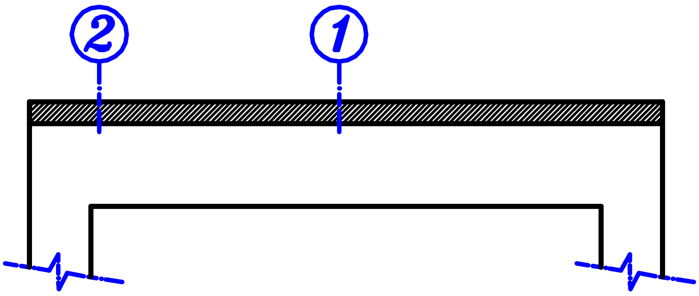
و نوجد له A_s فقط .

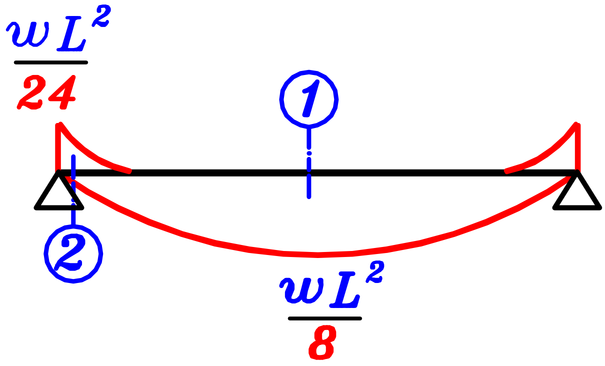


ملحوظه اذا كان d الكمره مُعطى فلن يفرق تصميم أى قطاع قبل الاخر .

الكمرات المقلوبه يكون نوع القطاع فيها عكس الكمره الساقطه

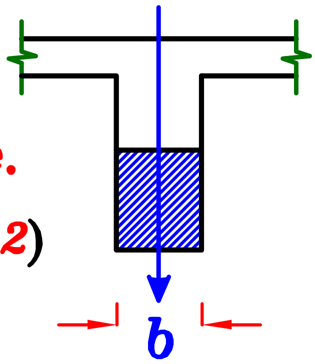
Projected Beam. كمره ساقطه

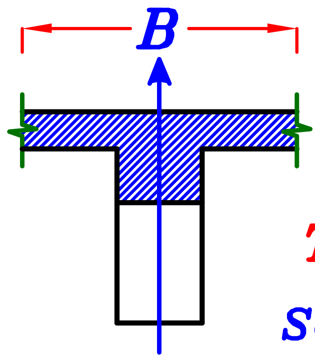




R–Sec.

Sec. (2–2)

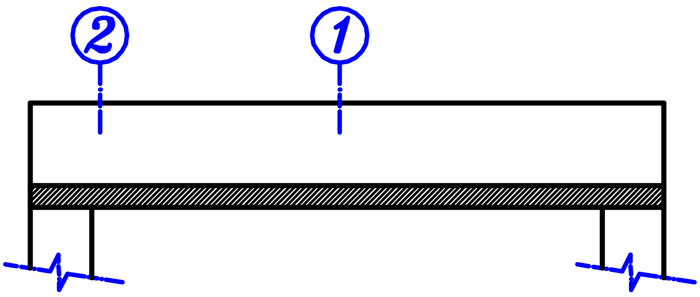


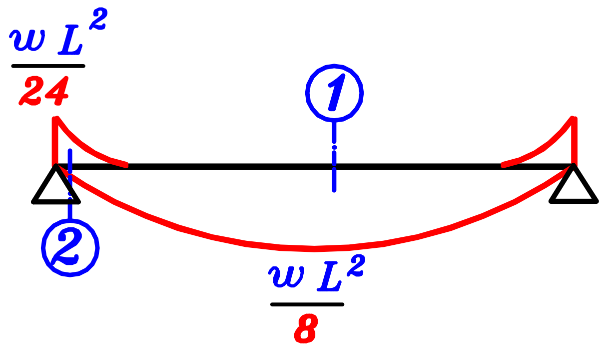


T–Sec.

Sec. (1–1)

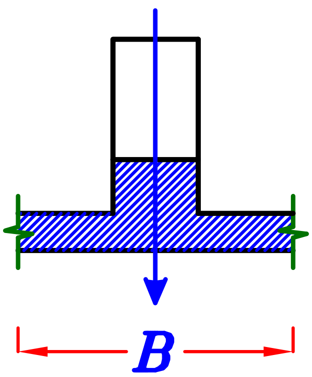
Inverted Beam. كمره مقلوبه

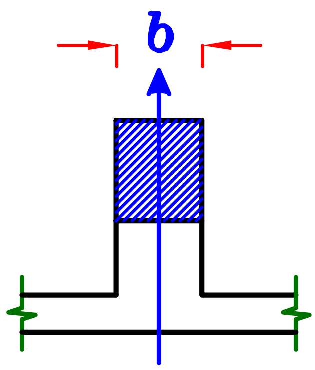




T–Sec.

Sec. (2–2)



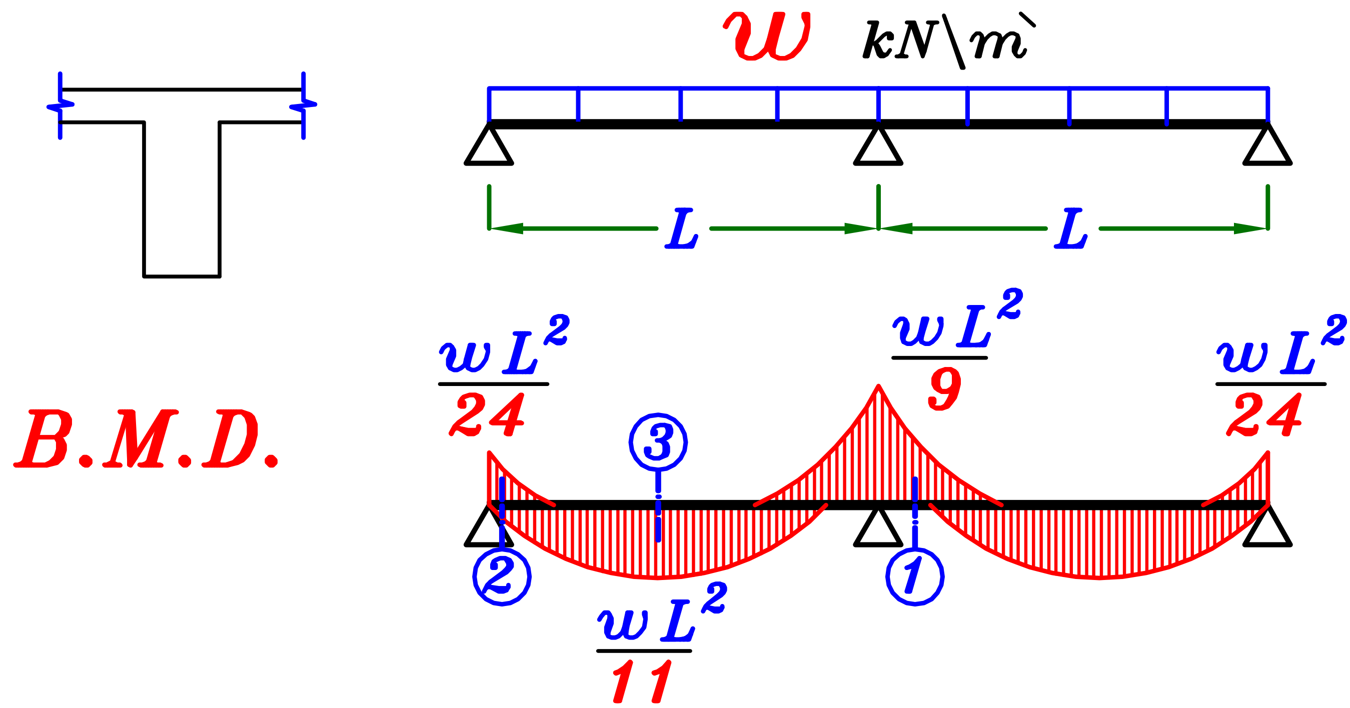


R–Sec.

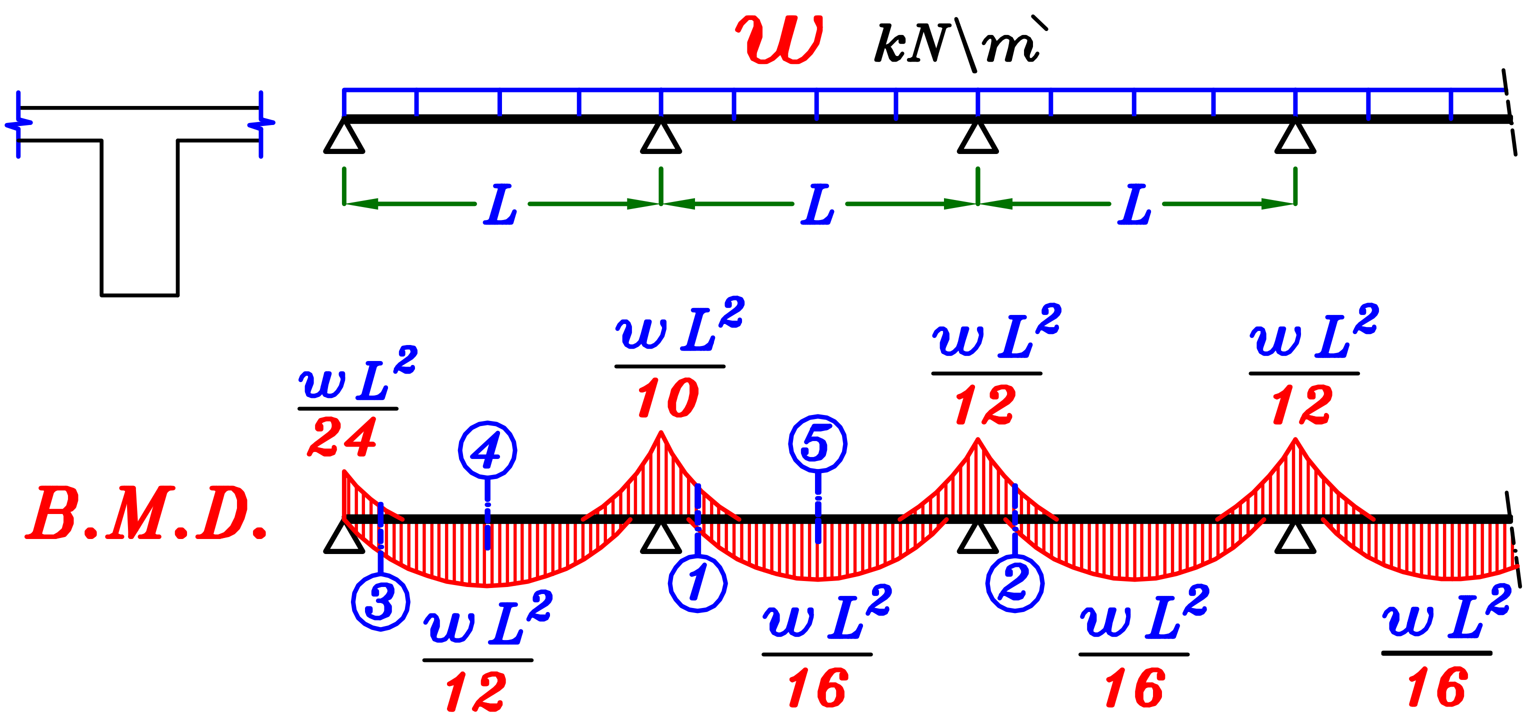
Sec. (1–1)

Continuous Beams.

① Continuous Beam with 2 spans.

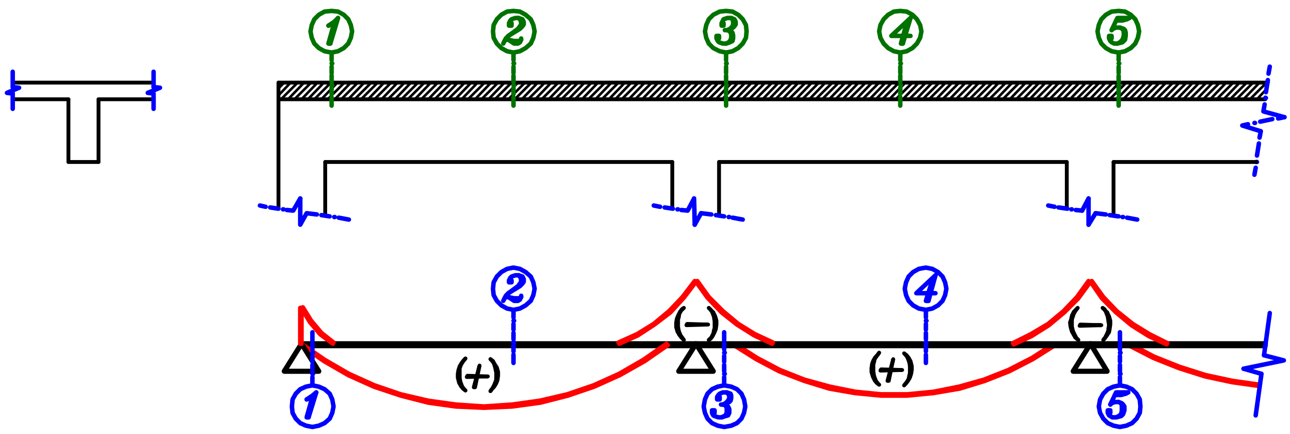


② Continuous Beam with more than 2 spans.



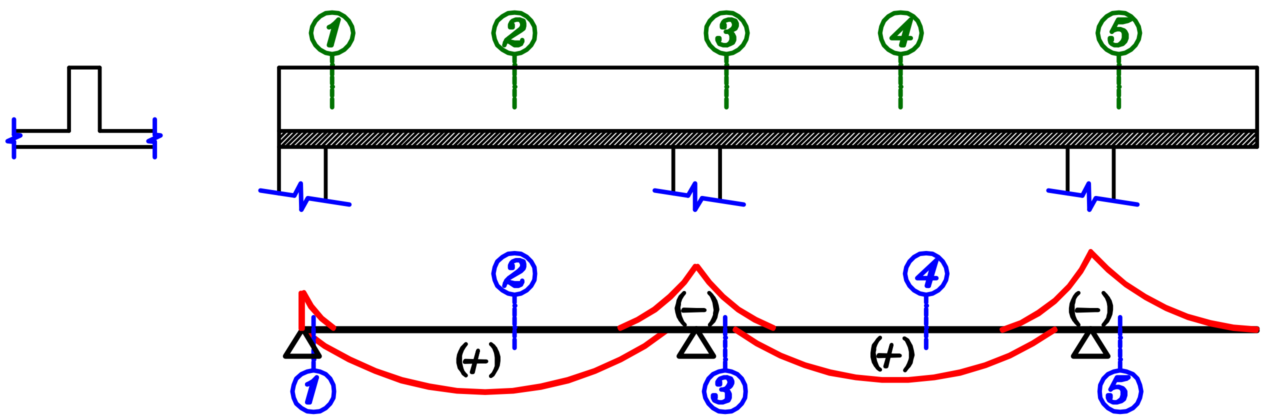
Example. Find the type of Sections.

Projected Beam. كمره ساقطه



Sec.	Sec. (1)	Sec. (2)	Sec. (3)	Sec. (4)	Sec. (5)
Type of Section	R−Sec.	T−Sec.	R−Sec.	T−Sec.	R−Sec.
K	——	0.8	——	0.7	——

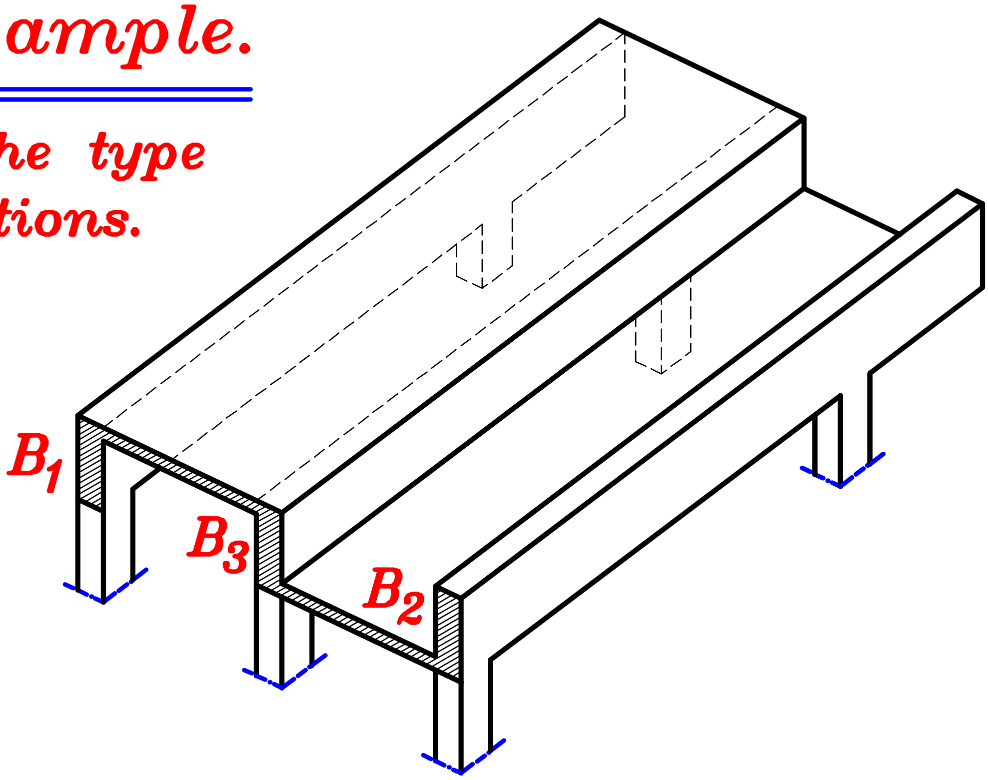
Inverted Beam. كمره مقلوبه



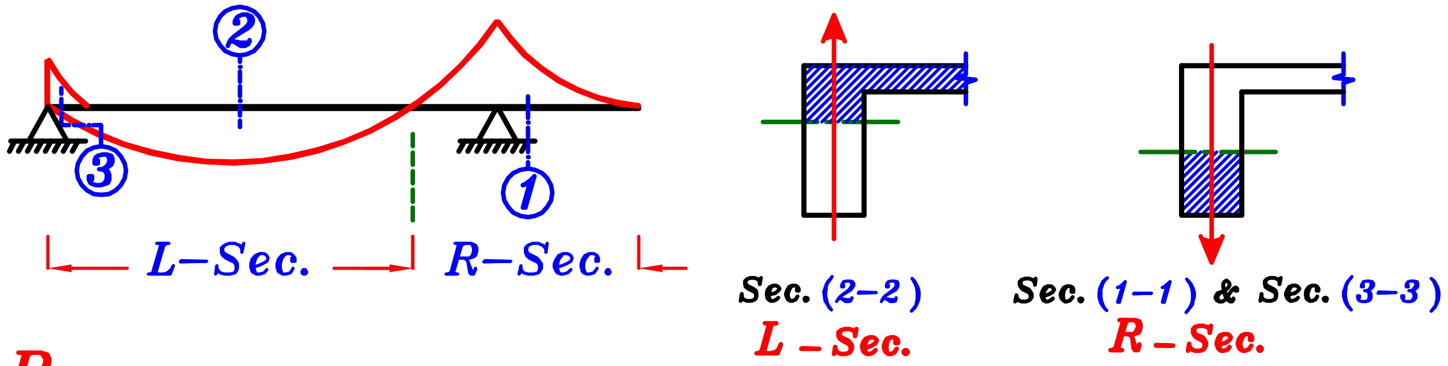
Sec.	Sec. (1)	Sec. (2)	Sec. (3)	Sec. (4)	Sec. (5)
Type of Section	T−Sec.	R−Sec.	T−Sec.	R−Sec.	T−Sec.
K	0.15	——	0.3	——	2.0

Example.

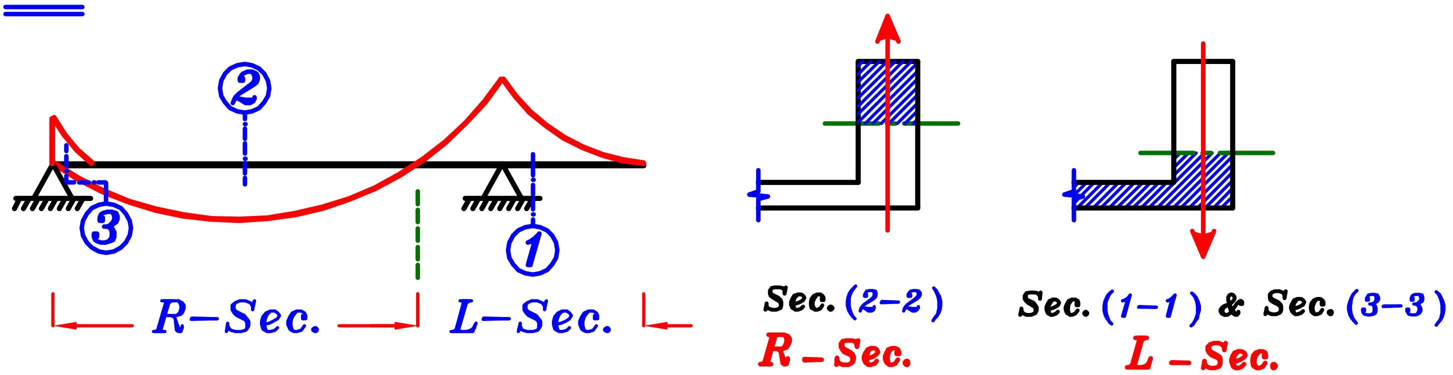
Find the type of Sections.



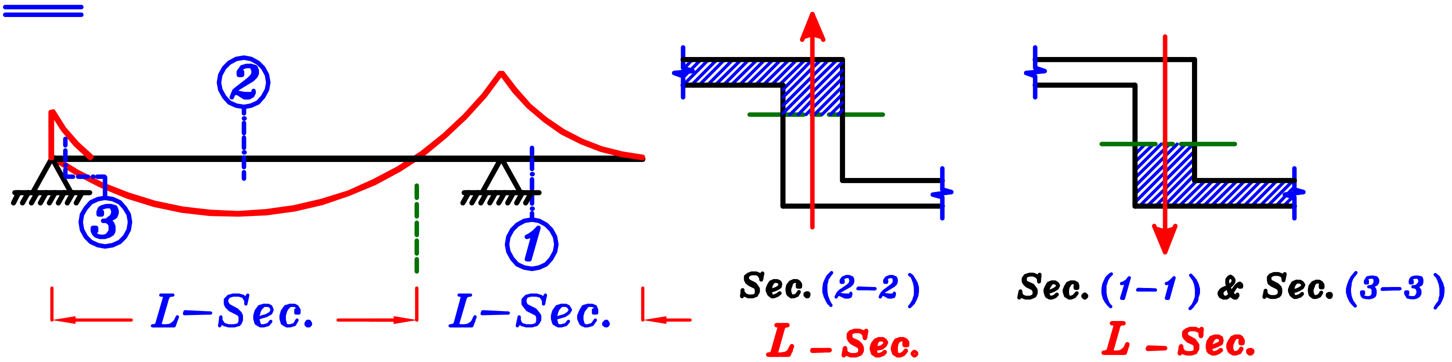
B_1



B_2

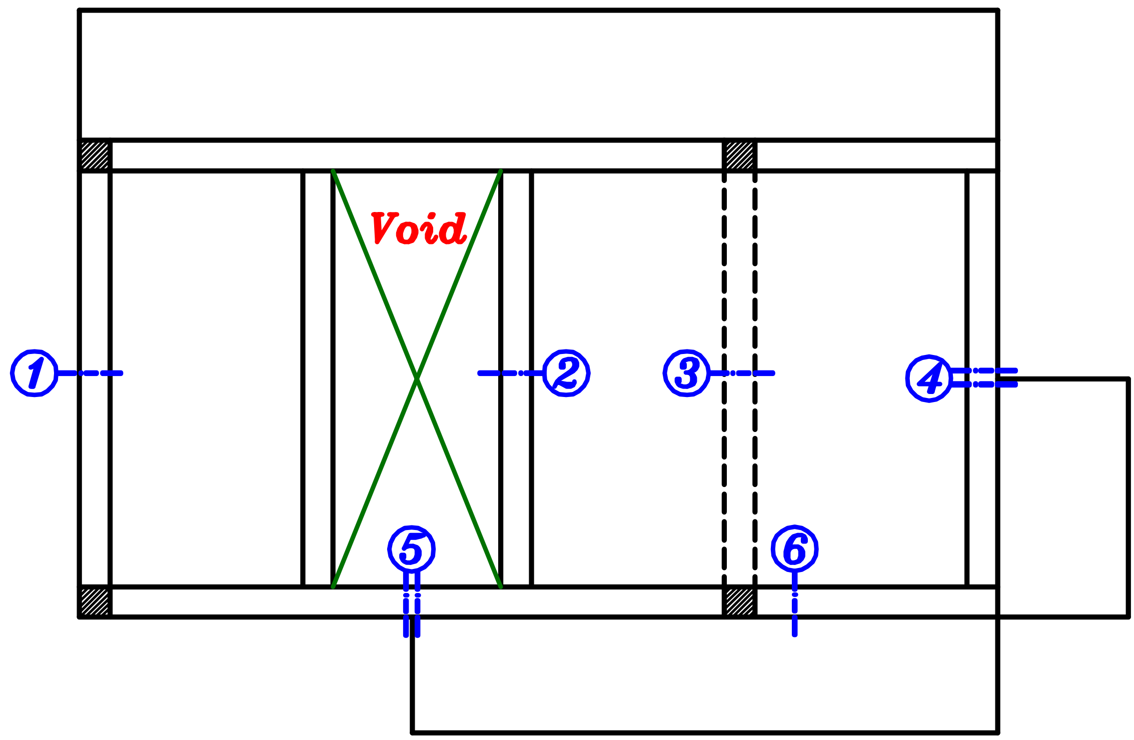


B_3

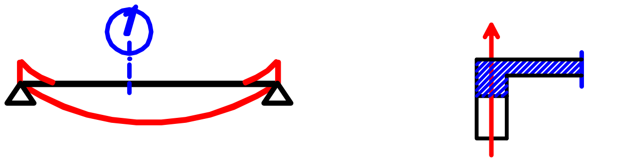


Example.

ملحوظه : إذا وُجّد قطاع ممكن أن يكون نوعان من القطاعات نصممة على القطاع الأضعف .

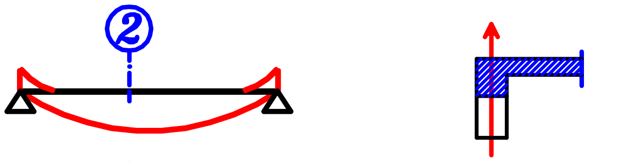


Sec. (1-1)



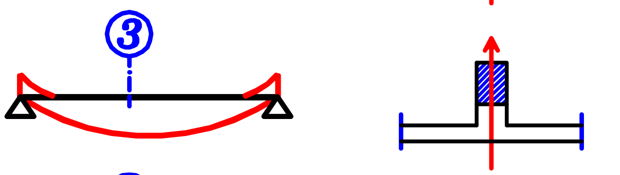
Designed as L-Sec.

Sec. (2-2)



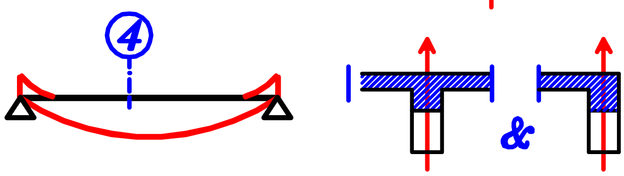
Designed as L-Sec.

Sec. (3-3)



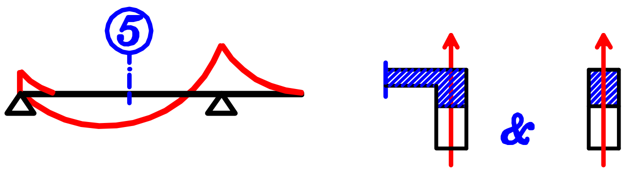
Designed as R-Sec.

Sec. (4-4)



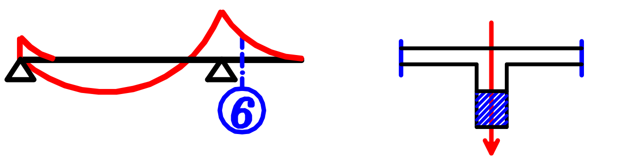
Designed as L-Sec.

Sec. (5-5)



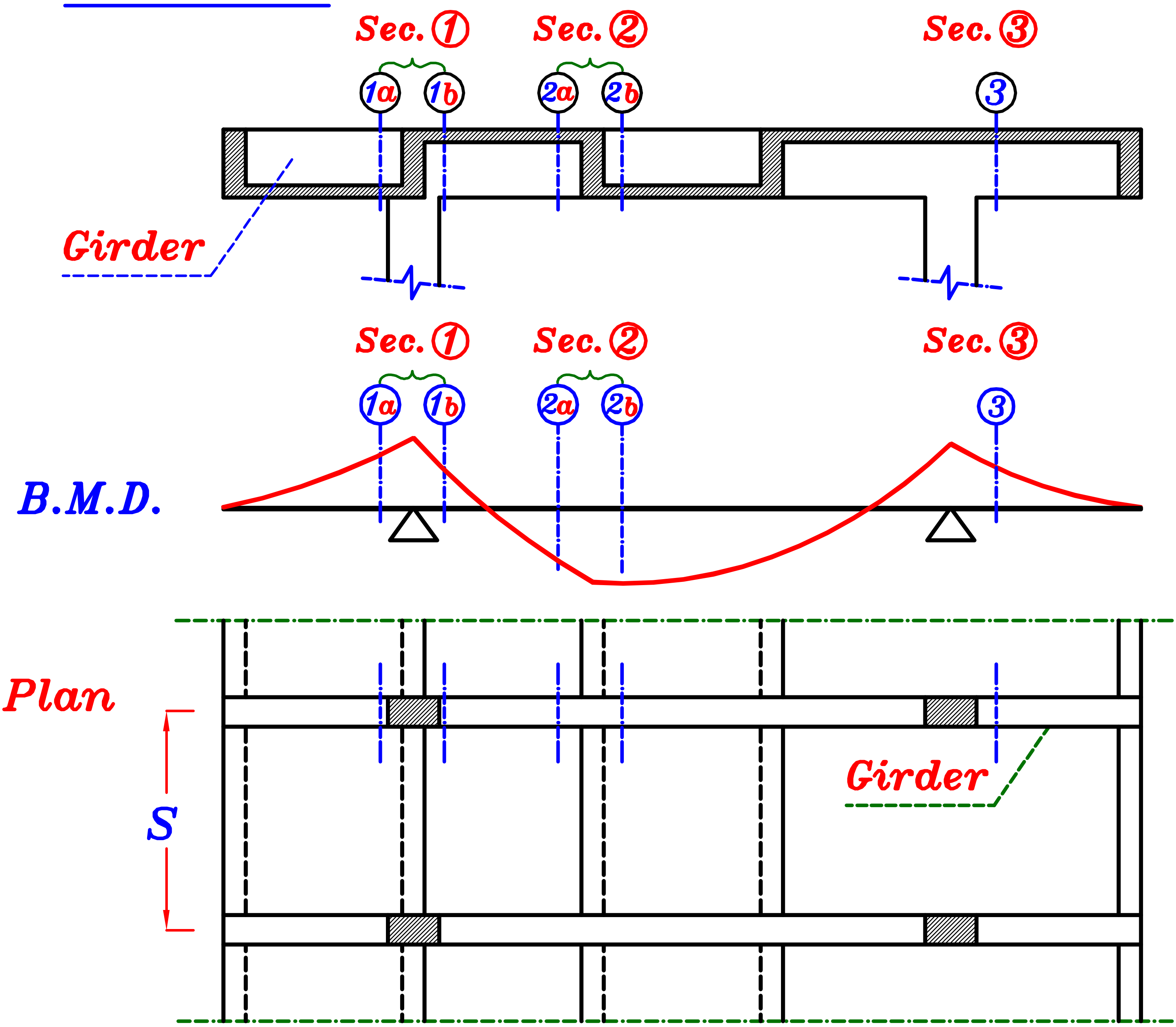
Designed as R-Sec.

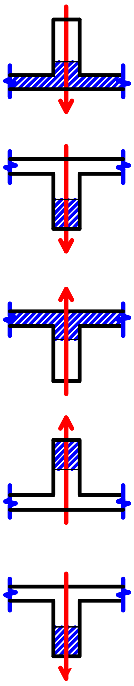
Sec. (6-6)



Designed as R-Sec.

Example.



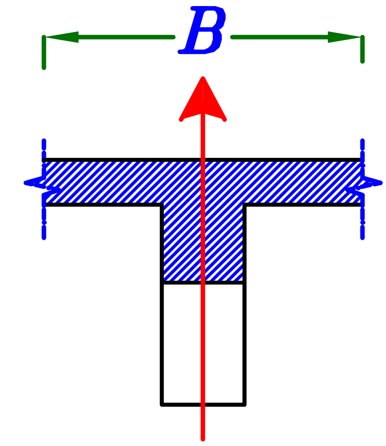


Sec. 1a — T-Sec.
Sec. 1b — R-Sec.
} Design Sec. 1 as R-Sec.

Sec. 2a — T-Sec.
Sec. 2b — R-Sec.
} Design Sec. 2 as R-Sec.

Sec. 3 — Design Sec. 3 as R-Sec.

Design of Sections with Inclined Slabs.

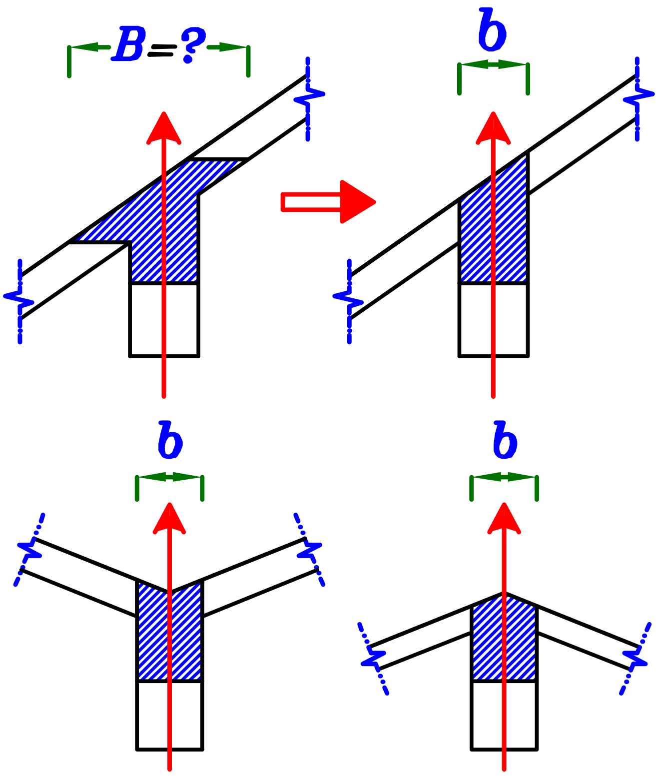


اذا كانت البلاطه ظاهره فى ال cross section أفقيه

ممكن ان نحسب قيمه B من القانون التالى

$$B = \left\{\begin{array}{l} \underset{slab}{C.L.} - \underset{slab}{C.L.} \\ 16\,t_s + b \\ K\,\frac{L}{5} + b \end{array}\right\}$$

الأقل



اما اذا كانت البلاطه ظاهره فى

ال cross section مائله

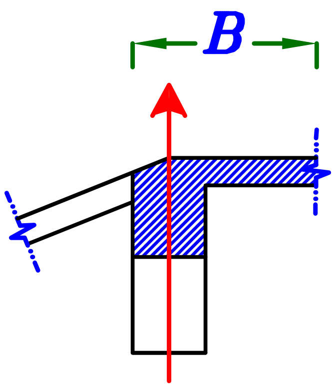
فلا توجد لدينا قوانين دقيقه

لحساب B

لذلك لزياده الامان نعتبر ان b فقط

هى من تقاوم فى القطاع

مثل ال R-Sec.



اما اذا كانت البلاطه ظاهره فى

ال cross section جهه مائله و جهه افقيه

ممكن حساب قيمه B من الجهه الافقيه فقط

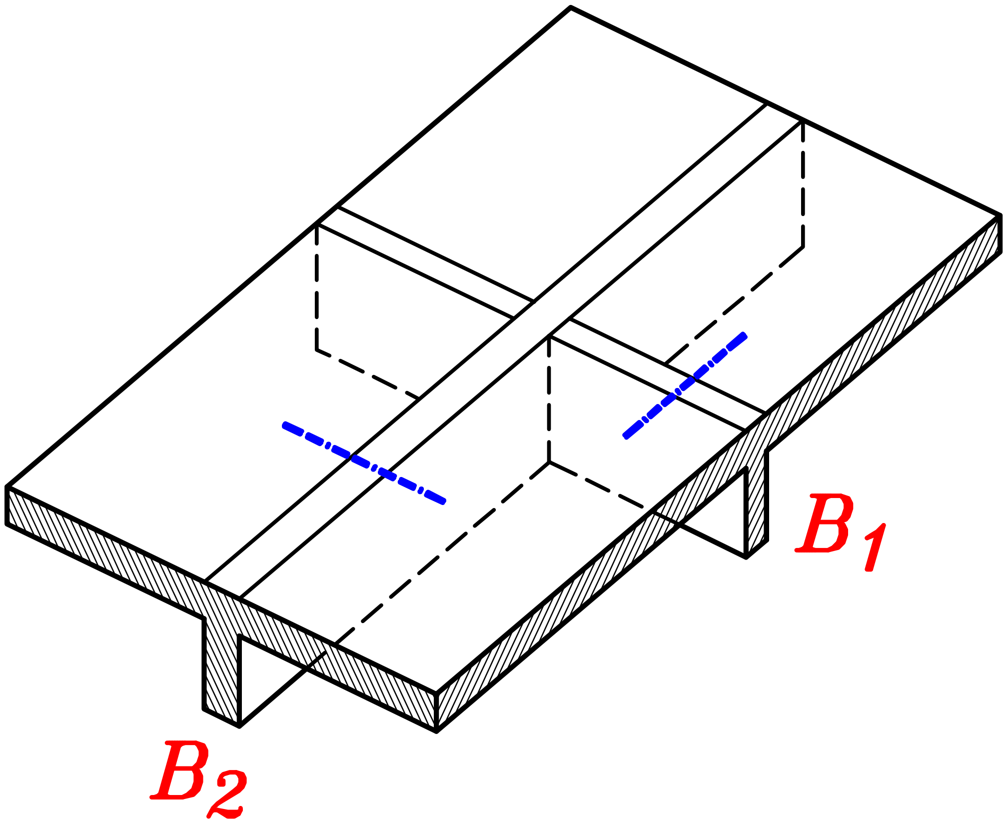
مثل L-Sec.

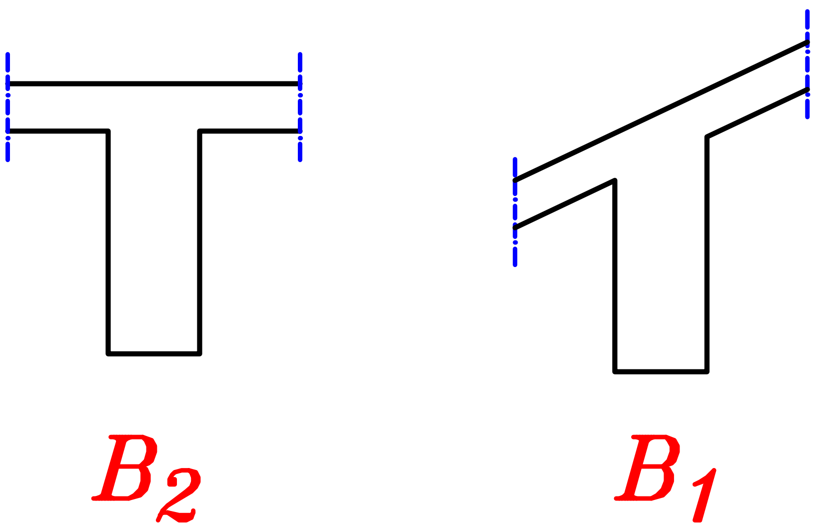
$$B = \left\{\begin{array}{l} \underset{beam}{C.L.} - \underset{slab}{C.L.} \\ 6\,t_s + b \\ K\,\frac{L}{10} + b \end{array}\right\}$$

الأقل

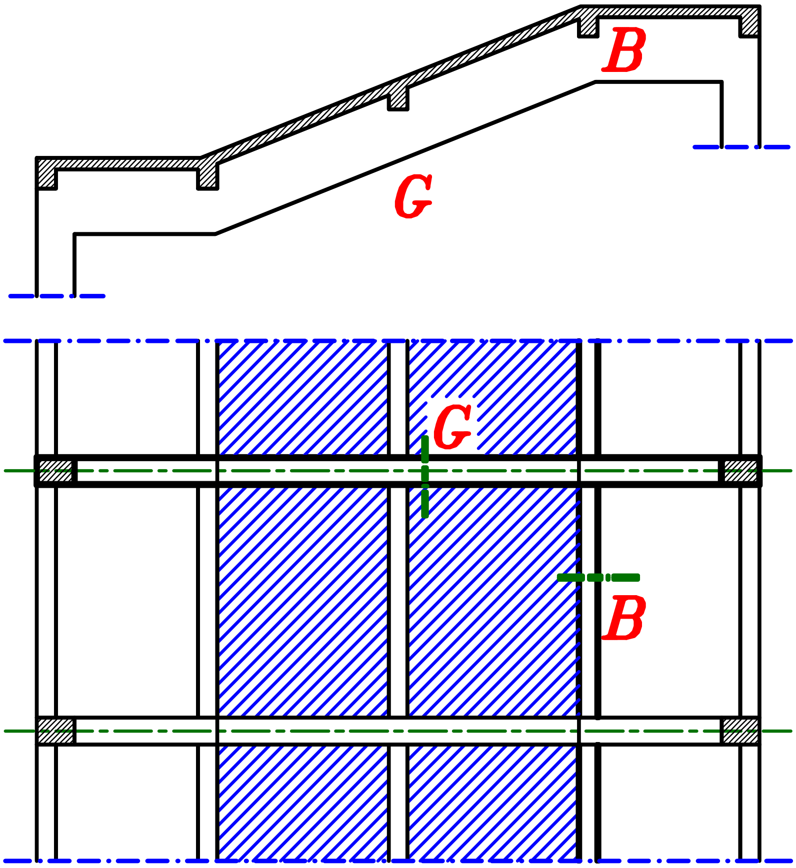
Note.

من الممكن ان تكون البلاطه فى الحقيقه مائله
لكن فى رسمه الـ *cross section* ممكن
ان تكون البلاطه شكلها افقى .

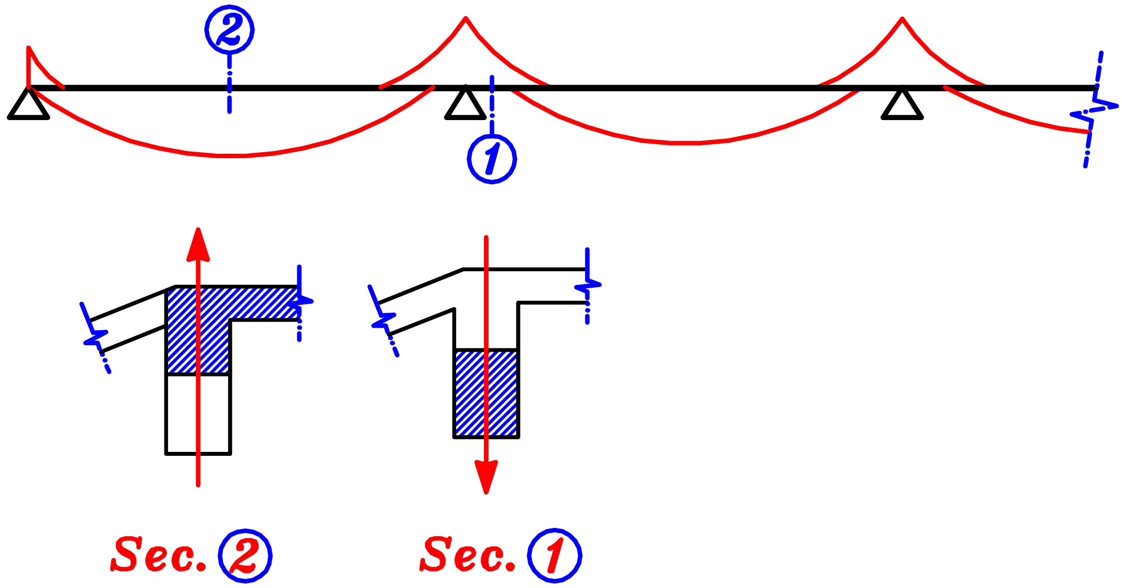




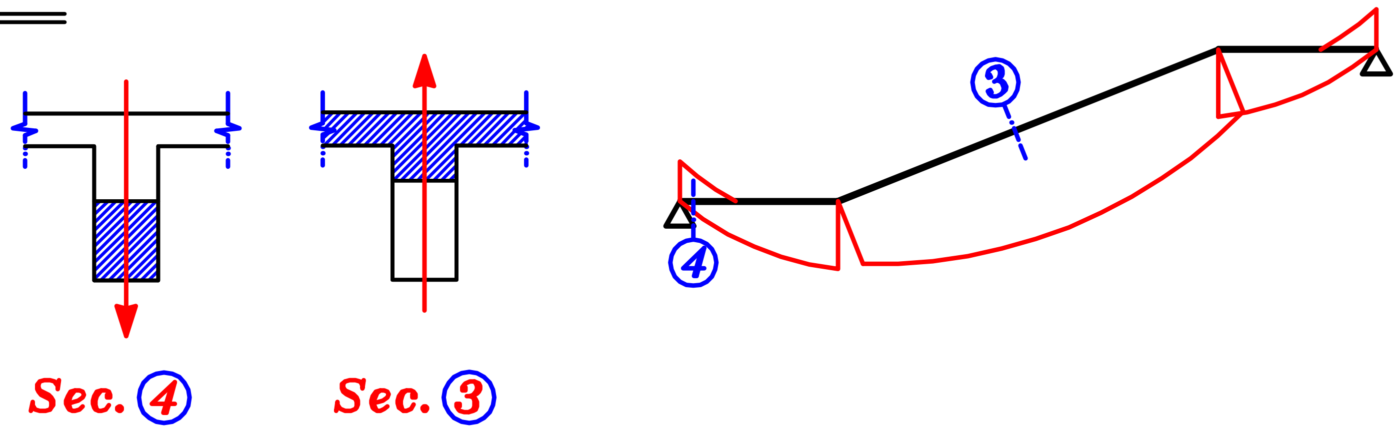
Example.



B



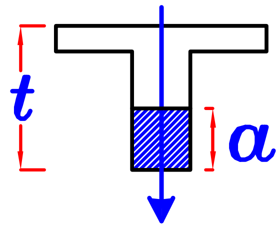
G



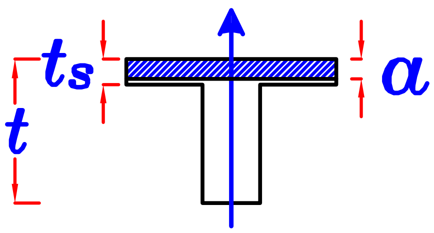
فى حاله d ليست معطاه

IF required to design the section using economic depth.

For R-sec. take $\boxed{a = 0.25\,d}$



For T-sec. or L-sec. take $\boxed{a = 0.9\ t_s}$



IF required to design the section using minimum depth.

For R-sec. take $a = a_{max}$ & $A_{s`} = A_{s`\,max}$

For T-sec. or L-sec. take $a = a_{max}$ without $A_{s`}$

Design of Section subjected to Double Moment.

اذا كانت الكمره يؤثر عليها M_Y و M_X معاً و لا يؤثر عليها P

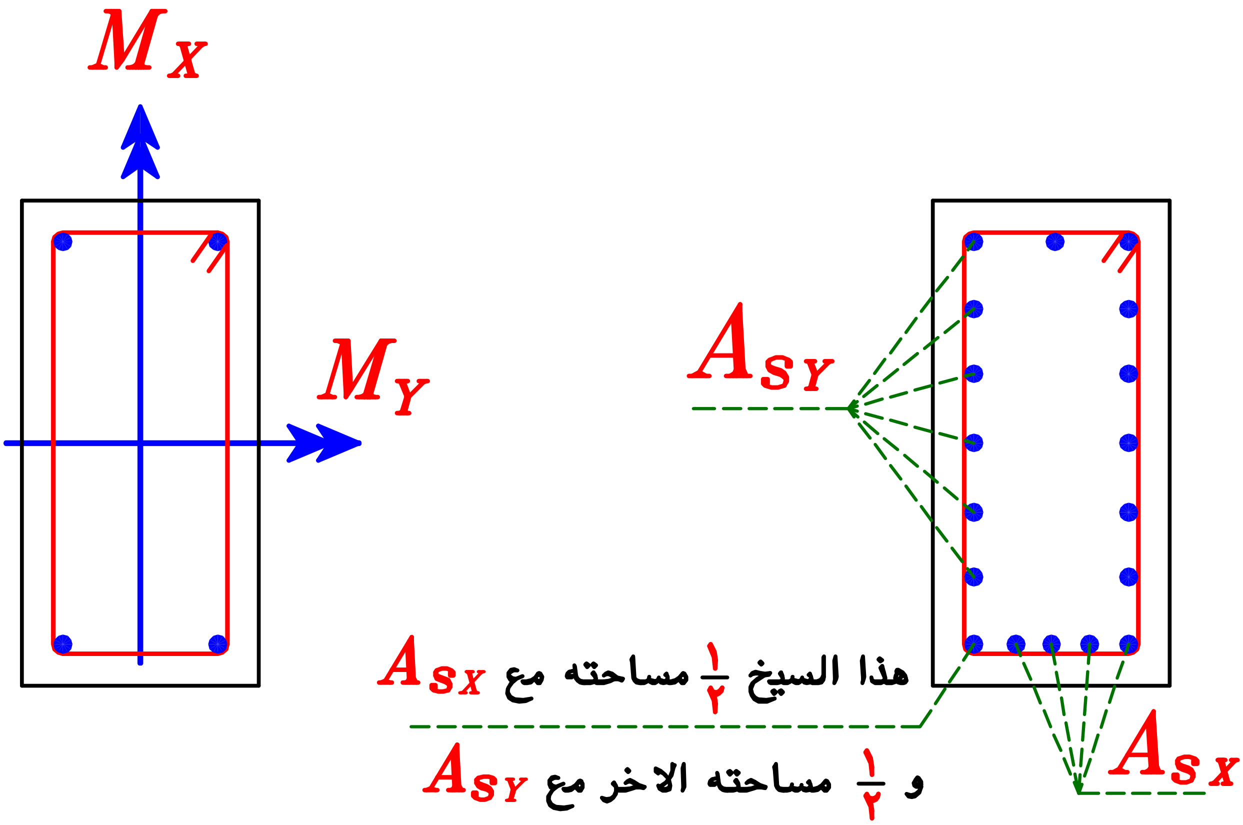
و يتم تصميم قطاع الكمره مرتين :

١- يتم تصميم قطاع الكمره على M_X فقط و تحديد قيمه A_{sX}

$$\text{Check} \quad A_{sX} > A_{s\,min} = \mu_{min.}\, b\, d \xrightarrow{\text{IF not}} \text{Take } A_{sX} = A_{s\,min}$$

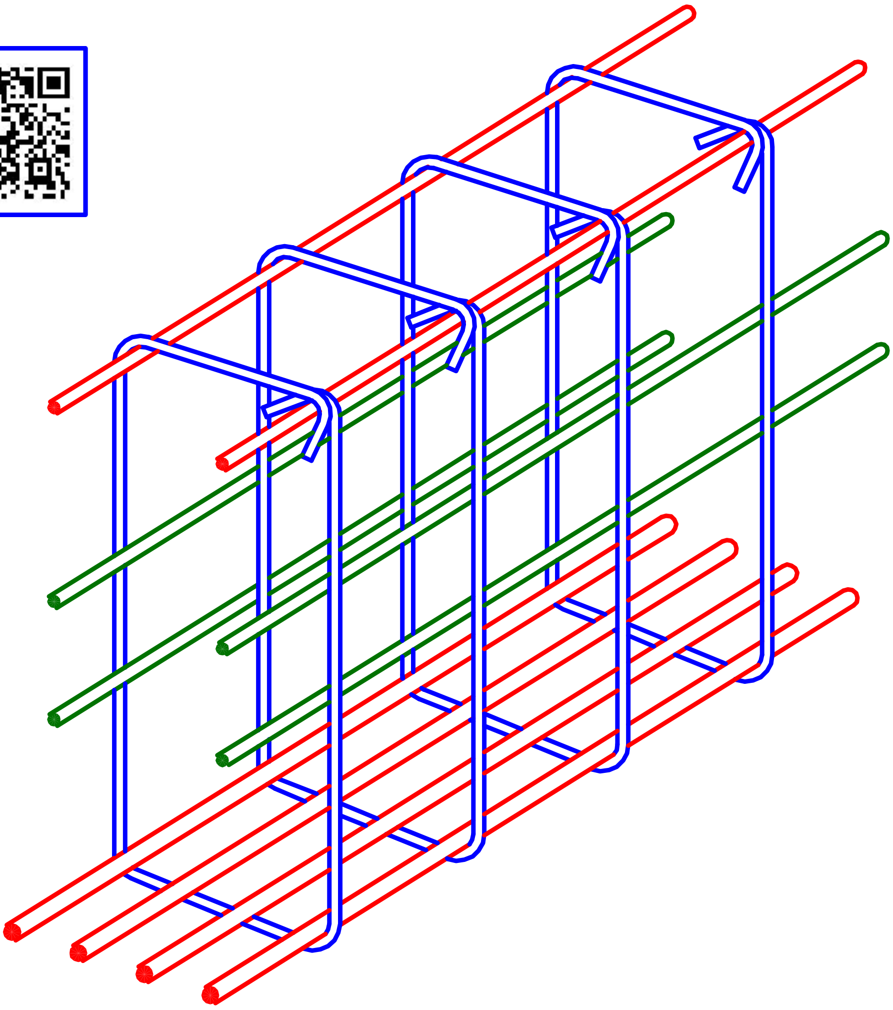
٢- يتم تصميم قطاع الكمره على M_Y فقط و تحديد قيمه A_{sY}

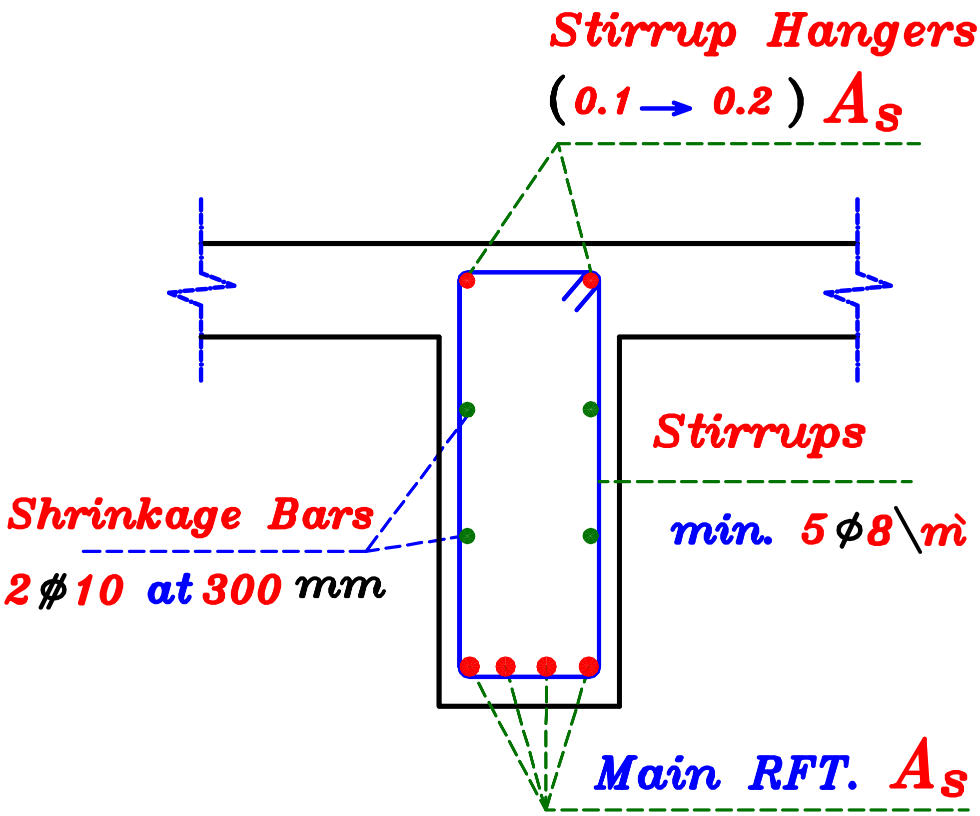
$$\text{Check} \quad A_{sY} > A_{s\,min} = \mu_{min.}\, b\, d \xrightarrow{\text{IF not}} \text{Take } A_{sY} = A_{s\,min}$$



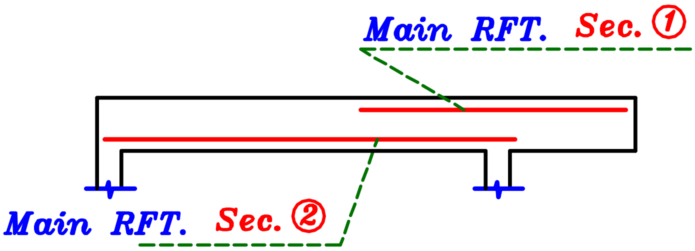
Reinforcement in Cross section.

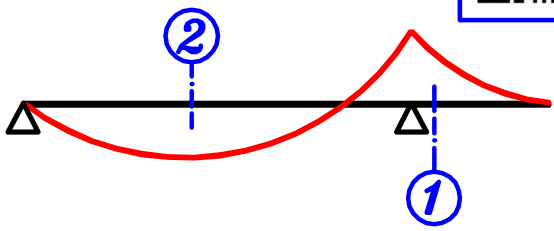
رسم التسليح داخل قطاع الكمره





① Main RFT. (A_s)





هو الحديد الرئيسى الموجود فى القطاع و يكون دائما جهه الشد أى يكون جهه ال **moment**

Choosing A_s

* min ϕ = ϕ 12   * max ϕ = ϕ 25
* max. No. of rows = 3 rows — أكبر عدد لصفوف التسليح يساوى ٣ صفوف .
* min. No. of bars in one row = 2 bars — أقل عدد أسياخ فى الصف الواحد تساوى ٢ سيخ .
* max. No. of bars in one row = n bar

أكبر عدد أسياخ ممكن وضعها فى الصف الواحد تساوى n

Calculation of max. No. of bars in one raw. (n)

To get n , we have to get min. spacing between bars (S)

$$S = \left\{ \begin{array}{l} 25 \ mm \\ \phi_{max} \\ \text{max. size of aggregate} + 5 \ m.m. \end{array} \right\}$$

الأكبر $\simeq 25 \ mm$

Take $\boxed{S = 25 \ mm}$

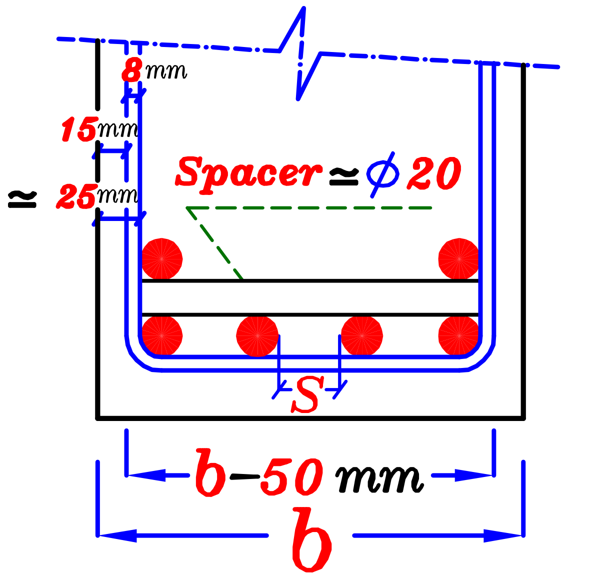
$$b - 50 = n\,\phi + (n-1)(S)$$

$$\therefore \ b - 50 = n\,\phi + (n-1)(25)$$

$$\therefore \ b - 50 = n\,(\phi + 25) - 25$$

$$\boxed{n = \frac{b-25}{\phi + 25}}$$

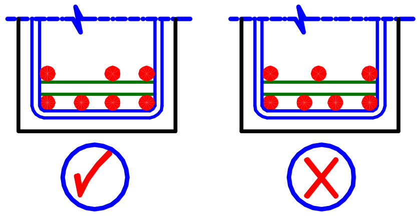
حفظ



Example.

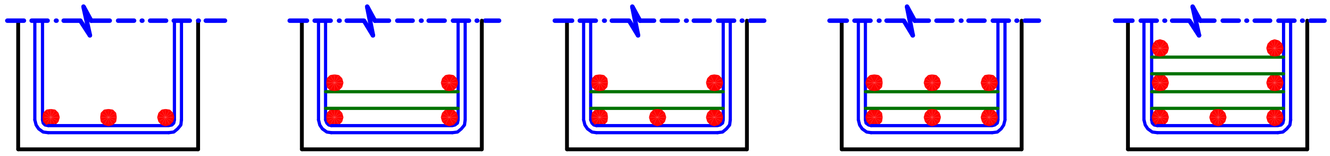
$b = 250$ mm , $\phi \ 16 = 16$ mm

$$\therefore \ n = \frac{b-25}{\phi+25} = \frac{250-25}{16+25} = 5.48 = 5.0 \text{ bars in one row.}$$



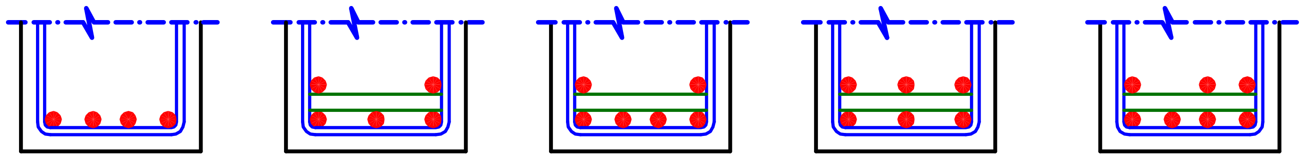
عند وجود أكثر من صف تسليح فى الكمره ·
يجب أن يكون كل سيخ فى الصف العوى
يكون أسفلة سيخ فى الصف السفلى·

IF $n = 3$



3 Bars | 4 Bars | 5 Bars | 6 Bars | 7 Bars

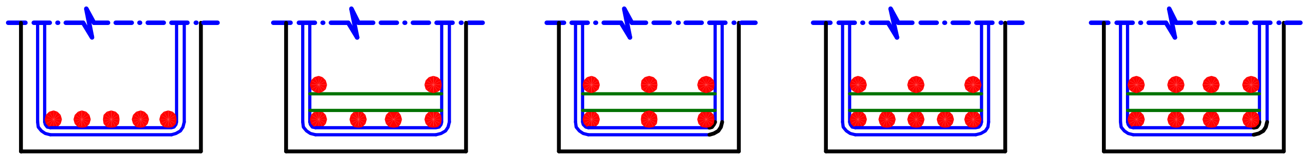
IF $n = 4$



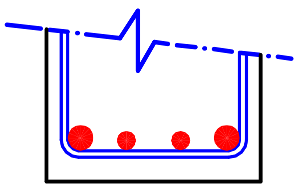
3 Bars | 4 Bars | 5 Bars | 6 Bars | 7 Bars

not a Symmetric Sec.

IF $n = 5$



5 Bars | 6 Bars | 7 Bars | 8 Bars | 9 Bars



2∅16+ 2∅18

* ممكن استخدام قطرين مختليفين فى الكمره بشروط ·

- أن يكونا متتاليان فى الجدول 12،16،18،20،22،25
- توضع الأسياخ ذات القطر الأكبر فى الأركان.
- نحاول على قدر الأمكان أن يكون القطاع Symmetric ·
- أقل عدد من الأسياخ من كل قطر = ٢ سيخ ·

Example.

3∅12 ------------- (✓)
2∅12 + 2∅16 ------ (✓)
2∅12 + 1∅16 ------ (✗)
2∅12 + 3∅16 ------ (✓)
2∅12 + 2∅18 ------ (✗)

Area of Steel

$$A_s = \checkmark \ mm^2$$

φ \ No.	1	2	3	4	5	6	7	8	9	10	11	12
6	28.3	56.6	84.9	113.2	141.5	169.8	198.1	226.4	198.1	283	311.3	339.6
8	50.3	100.6	150.9	201.2	251.5	301.8	352.1	402.4	452.7	503	553.3	603.6
10	78.5	157	235.5	314	392.5	471	549.5	628	706.5	785	863.5	942
12	113	226	339	452	565	678	791	904	1017	1130	1243	1356
13	133	266	399	532	665	798	931	1064	1197	1330	1463	1596
16	201	402	603	804	1005	1206	1407	1608	1809	2010	2211	2412
18	254	508	762	1016	1270	1524	1778	2032	2286	2540	2794	3048
19	283	566	849	1132	1415	1698	1981	2264	2547	2830	3113	3396
20	314	628	942	1256	1570	1884	2198	2512	2826	3140	3454	3768
22	380	760	1140	1520	1900	2280	2660	3040	3420	3800	4180	4560
25	491	982	1473	1964	2455	2946	3437	3928	4419	4910	5401	5892
28	616	1232	1848	2464	3080	3696	4312	4928	5544	6160	6776	7392

الاقطار المشهوره فى مصر الوقت الحالى

φ \ No.	1	2	3	4	5	6	7	8	9	10	11	12
8	50.3	100.6	150.9	201.2	251.5	301.8	352.1	402.4	452.7	503	553.3	603.6
10	78.5	157	235.5	314	392.5	471	549.5	628	706.5	785	863.5	942
12	113	226	339	452	565	678	791	904	1017	1130	1243	1356
16	201	402	603	804	1005	1206	1407	1608	1809	2010	2211	2412
18	254	508	762	1016	1270	1524	1778	2032	2286	2540	2794	3048
20	314	628	942	1256	1570	1884	2198	2512	2826	3140	3454	3768
22	380	760	1140	1520	1900	2280	2660	3040	3420	3800	4180	4560
25	491	982	1473	1964	2455	2946	3437	3928	4419	4910	5401	5892

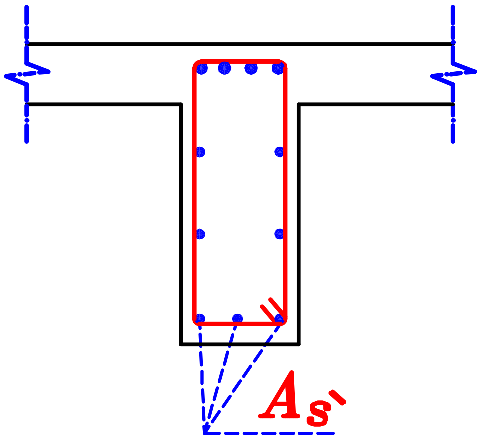
② Compressive Steel (A_s`)

و هو الحديد الذى يوضع فى منطقة الضغط إذا ما إحتاج القطاع إلى ذلك .

ممكن وضع الـ A_s` فى الـ R-Sec. فقط

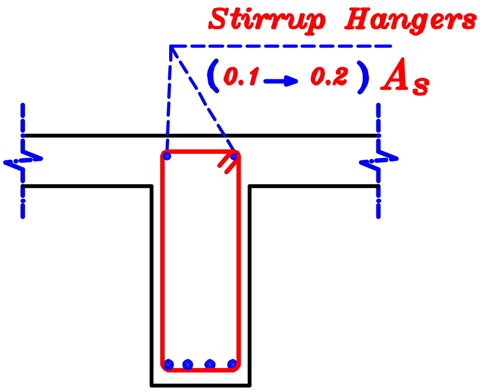
و لا يمكن وضعة فى الـ T-Sec. & L-Sec.

$$\boxed{A_{s\,max.}` = 0.40\ A_s}$$

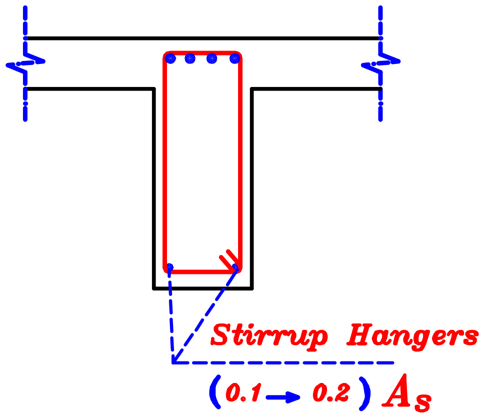


R-Sec.

③ Stirrup Hangers. تعليق الكانات



T-Sec.

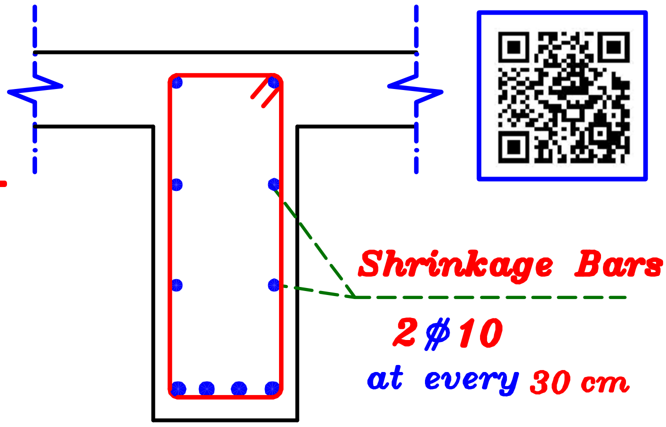


R-Sec.

- هى أسياخ توضع فى جهه الضغط إذا لم نحتاج الى A_s` .
- وظيفتها هى تعليق الكانات عليها لذا تسمى Stirrup Hangers .
- تعتبر الـ Stirrup Hangers عباره عن Secondary Steel . أى أننا نهمل وجودها فى الحسابات .
- توضع الـ Stirrup Hangers فى كلاً من R-Sec. & L-Sec. & T-Sec.
- قيمه الـ Stirrup Hangers فى القطاع تكون الأكبر من .

$$\text{الأكبر}\left\{\begin{array}{ll} (0.1 \rightarrow 0.2)\ A_s & \\ 2\phi 10 & \text{Beams} \\ 2\phi 12 & \text{Frames} \end{array}\right.$$

④ Shrinkage Bars.

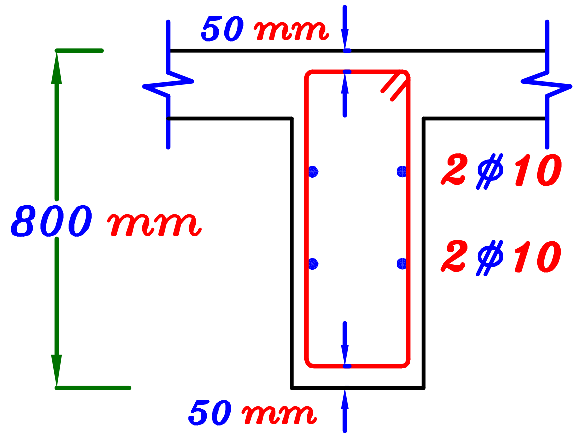


- و هى عباره عن أسياخ حديد توضع فى جانبى الكمره لتقلل الشروخ الناجمه عن انكماش الخرسانه .

- و نحتاج الـ Shrinkage Bars فقط عندما تكون $\boxed{t > 700\ mm}$

- قيمة الـ Shrinkage Bars هى الأكبر من
  - $0.08\ A_s$
  - ✓✓ 2ϕ10 at every 300 mm

Example.

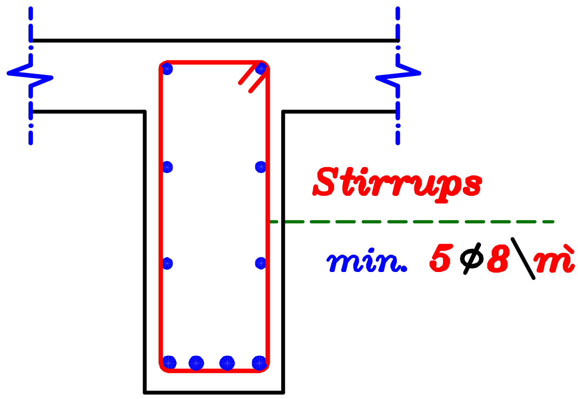


IF $t = 800\ mm$

$\therefore$ No. of Spacings $= \dfrac{800 - 100}{300}$

$= 2.33 = 3.0$ Spacing $\longrightarrow$ 2.0 Bars

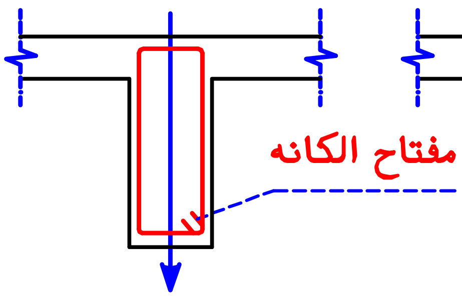
⑤ Stirrups. الكانات

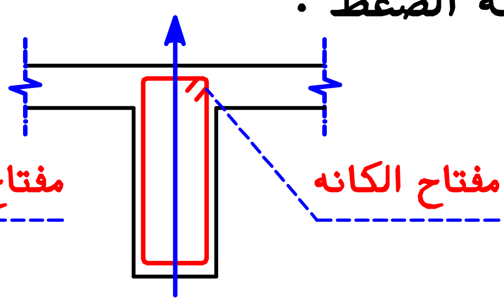


توضع الكانات فى الكمرات لـ

- مقاومه الـ Shear Stress .
- للربط بين الخرسانه فى منطقه الضغط و الحديد فى منطقه الشد .

- أقل قيمه للكانات فى الكمره هى 5ϕ8\m' .
- مفتاح الكانه يكون دائما جهه الضغط .





Example.

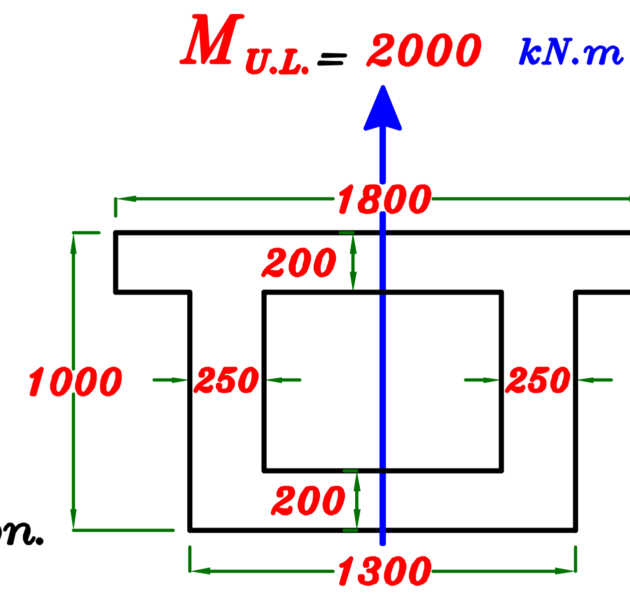
$F_{cu} = 25 \ N\backslash mm^2$

, st. 360/520

$M_{U.L.} = 2000 \ kN.m$

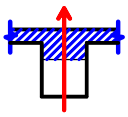
Design the section.

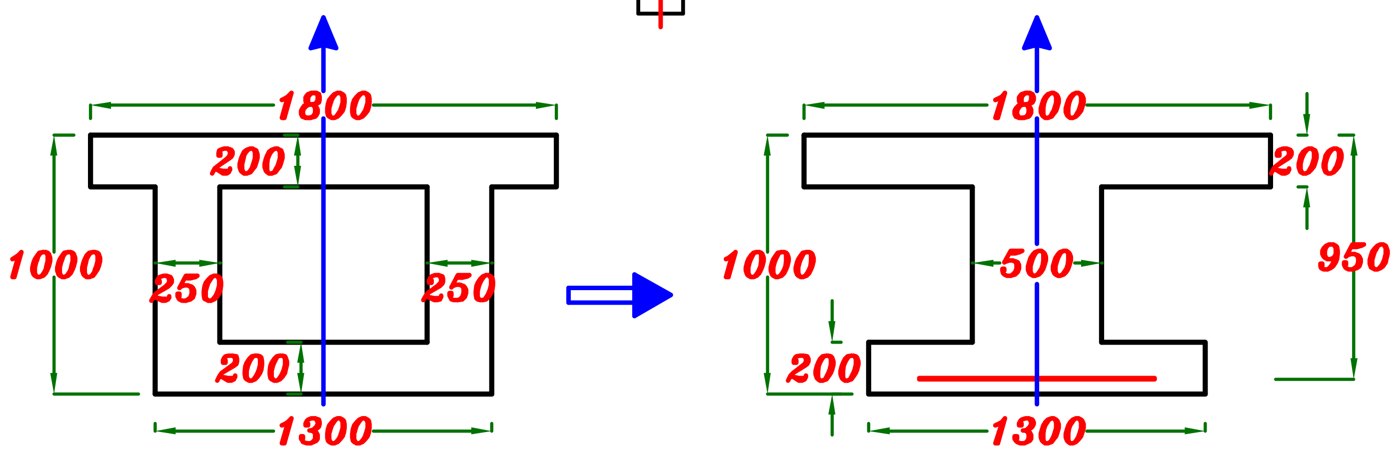
Draw details of RFT. in section.



Solution.

T–Sec.

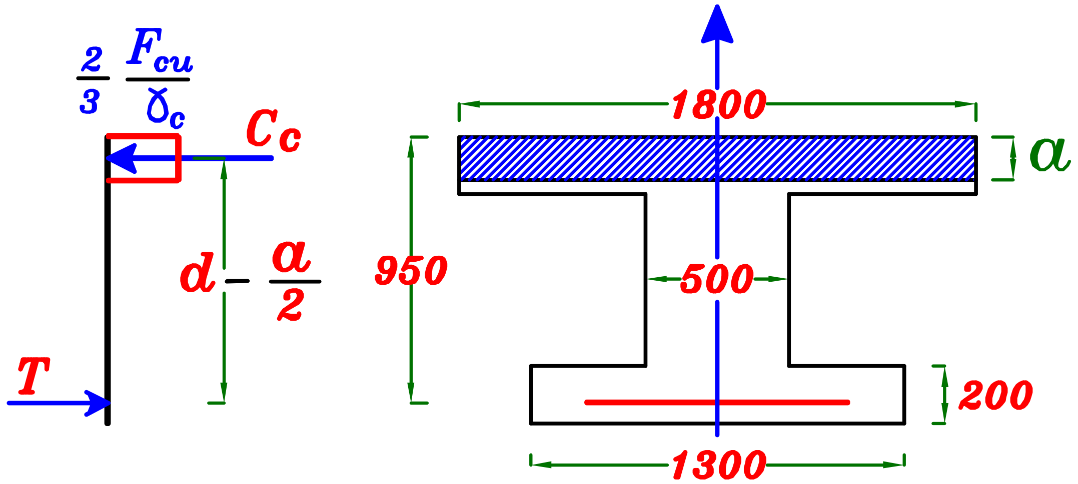




$$-M_{Flange} = \frac{2}{3}\frac{F_{cu}}{\gamma_c} t_s B \left(d - \frac{t_s}{2}\right) = \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(1800)\left(950 - \frac{200}{2}\right)$$

$$= 3400000000 \ N.mm = 3400 \ kN.m$$

$$\therefore M_{U.L.} < M_{Flange} \longrightarrow a < t_s$$



$$a_{min} = 0.10\,d = 0.10 * 1000 = 100\ mm$$

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \gamma_s)}\right] * d = 0.35\,d = 0.35 * 1000 = 350\ mm$$

$$-\ \text{Get}\ a\ \text{From}\quad M_{U.L.} = \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\,a\,B\left(d - \frac{a}{2}\right)$$

$$\therefore\ 2000 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(a)(1800)\left(950 - \frac{a}{2}\right)$$

$$\therefore\ \boxed{a = 111.85\,mm} \qquad \therefore\ a_{min} < a < a_{max} \qquad \therefore\ o.k.$$

Get A_s From Compression Force = Tension Force

$$\boxed{C_c = T} \qquad \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\,a\,B = A_s * \frac{F_y}{\gamma_s}$$

$$\therefore\ \frac{2}{3}\left(\frac{25}{1.5}\right)(111.85)(1800) = A_s * \left(\frac{360}{1.15}\right) \longrightarrow A_s = 7145.97\ mm^2$$

Check $A_{s_{min.}}$ $\therefore\ A_{s_{req.}} = 7145.97\ mm^2$

b أصغر

$$\mu_{min.}\,b\,d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\,d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 500 * 950 = 1484\ mm^2$$

$$\therefore\ A_{s_{req.}} > \mu_{min.}\,b\,d \qquad \therefore\ \text{Take}\ A_s = A_{s_{req.}} = 7145.97\,mm^2$$

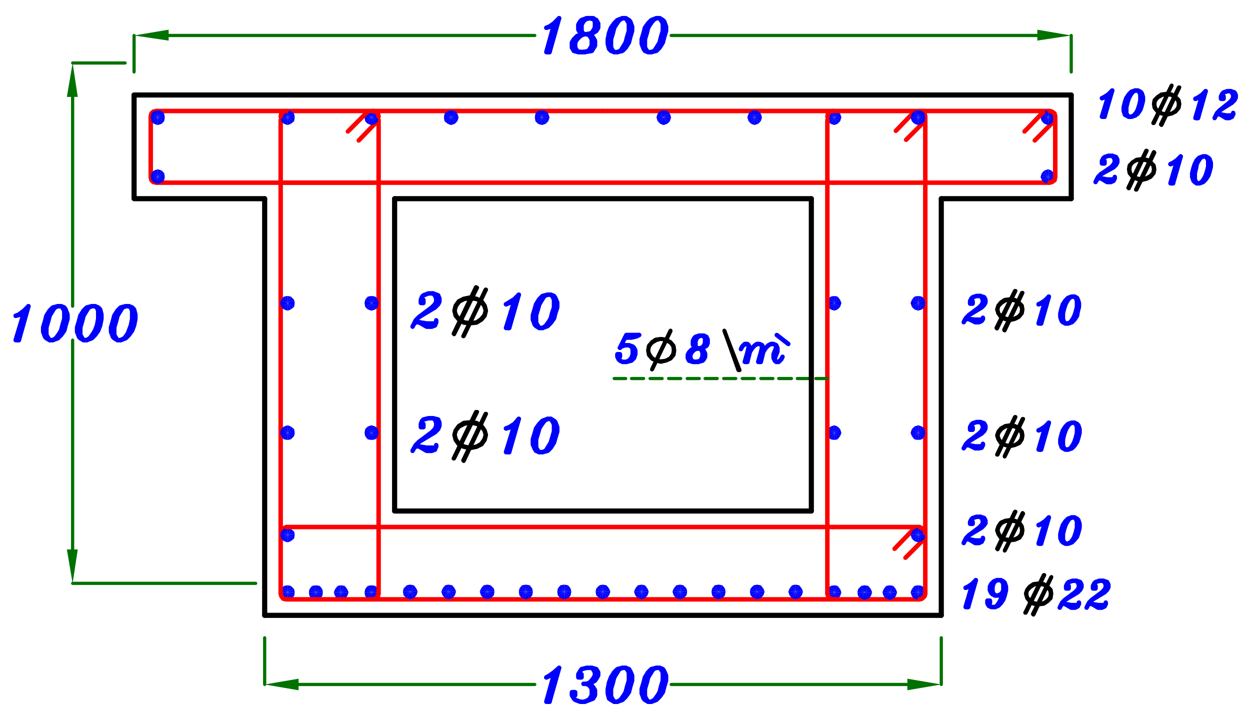
19ϕ22

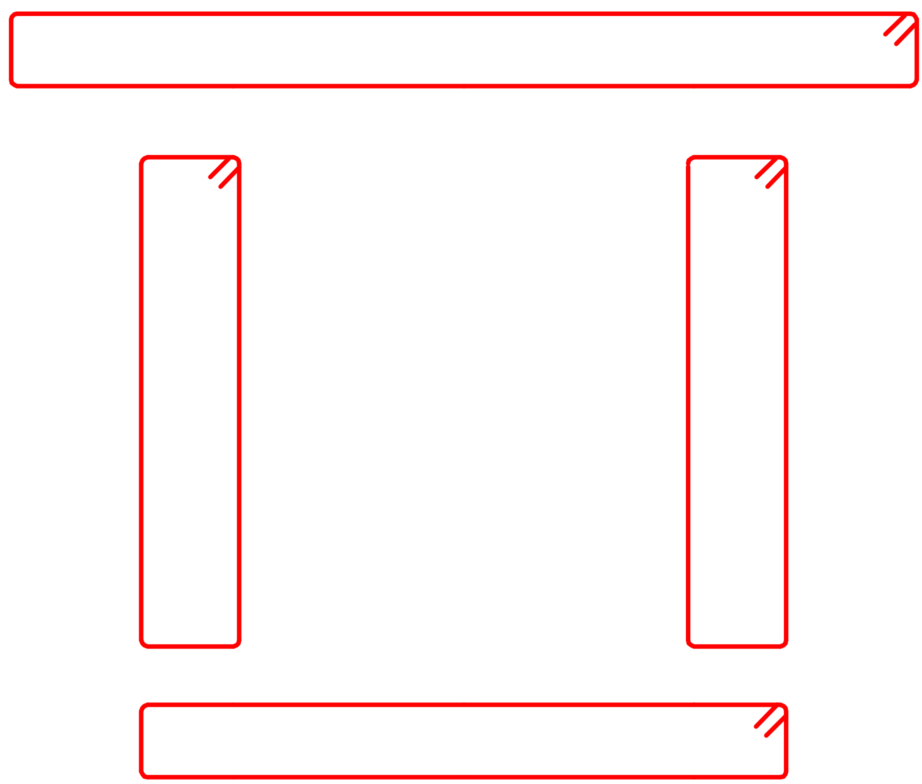
$$\therefore\ n = \frac{b - 25}{\phi + 25} = \frac{1300 - 25}{22 + 25} = 27.1 = 27.0$$

Stirrup Hangers $= (0.1 \rightarrow 0.2)\,A_s = (0.1 \rightarrow 0.2)\ 7145.97$ 10ϕ12

A_s = 19 ϕ 22

Stirrup Hangers = 10 ϕ 12





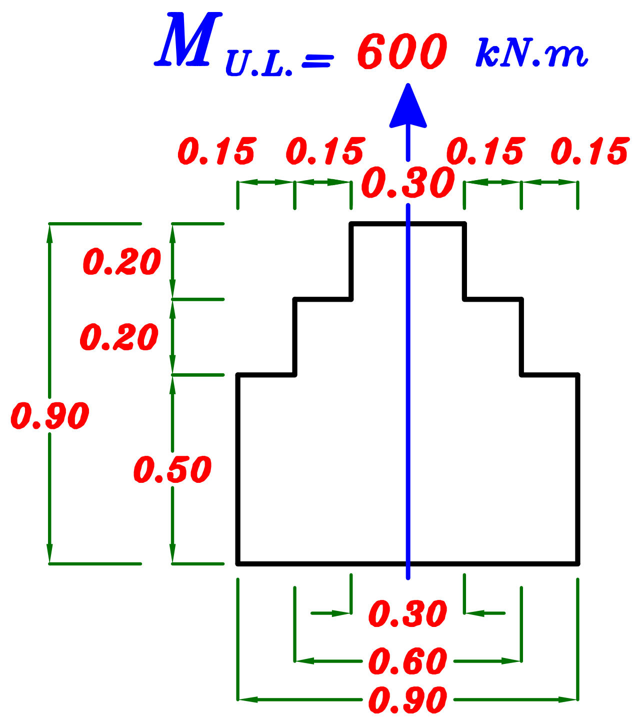
Example.

$F_{cu} = 25 \; N\backslash mm^2$

$, \; st. \; 360/520$

$M_{U.L.} = 600 \; kN.m$

Get A_s



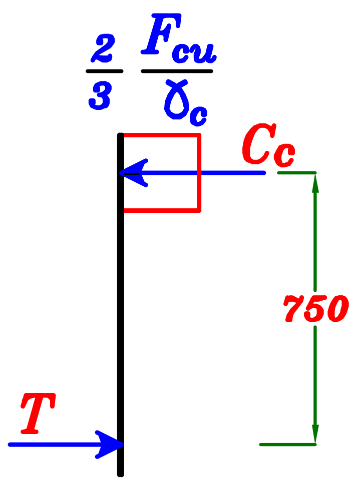
Solution.

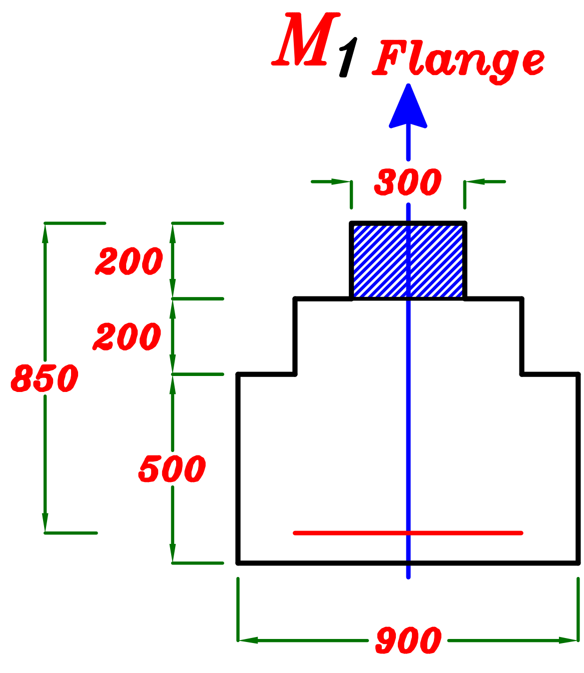
$$a_{min} = 0.10\, d = 0.10 * 850 = 85.0 \; mm$$

$$a_{max} = 0.8 \left(\frac{2}{3}\right) \left[\frac{600}{600 + (F_y \backslash \gamma_s)} \right] * d = 0.35\, d = 0.35 * 850 = 297.5 \; mm$$

assume

$a = 200 \; mm$



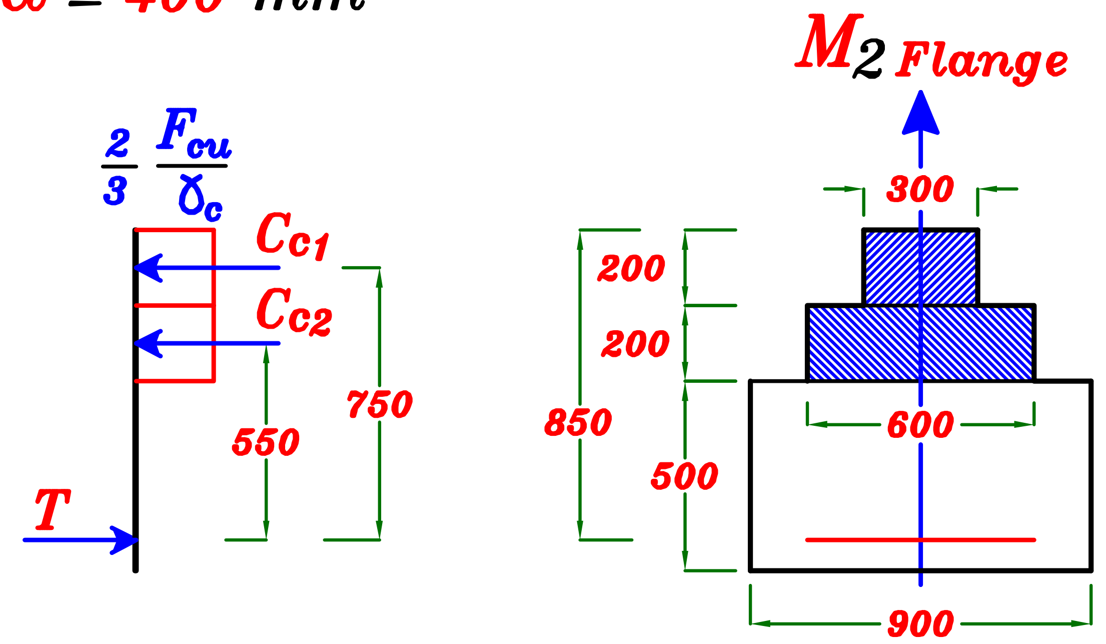


$$- M_{1\,Flange} = \frac{2}{3} \frac{F_{cu}}{\gamma_c} t_s \, b \, (750) = \frac{2}{3} \left(\frac{25}{1.5}\right)(200)(300)(750)$$

$$= 500000000 \; N.mm = 500 \; kN.m$$

$$\therefore M_{U.L.} > M_{Flange} \longrightarrow a > 200 \; mm$$

assume $a = 400$ mm

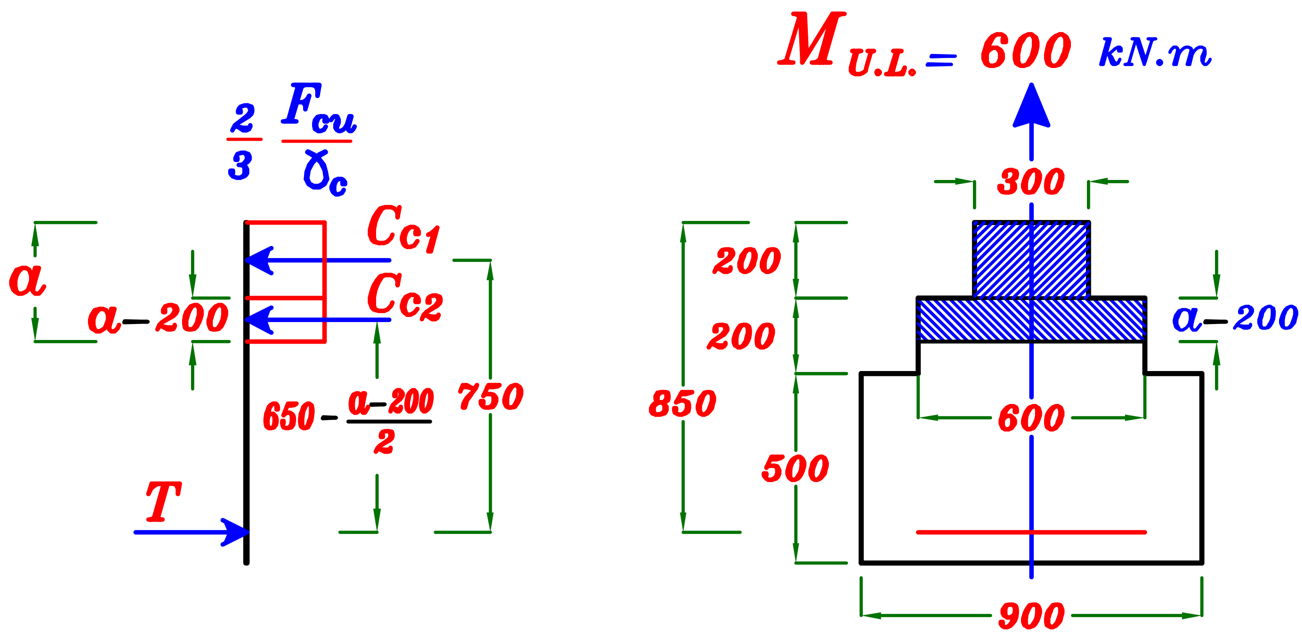


$$-M_{2\,Flange} = \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(300)(750) + \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(600)(550)$$

$$= 1233333333 \text{ N.mm} = 1233.3 \text{ kN.m}$$

$\because M_{1\,Flange} < M_{U.L.} < M_{2\,Flange}$ $\therefore$ $\boxed{200\text{ mm} < a < 400 \text{ mm}}$

$M_{U.L.} = 600$ kN.m



$$C_{c1} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}(200)(300) = \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(300)$$

$$C_{c2} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}(a-200)(600) = \frac{2}{3}\left(\frac{25}{1.5}\right)(a-200)(600)$$

Get a From

$$M_{U.L.} = C_{c1}(750) + C_{c2}\left(650 - \frac{a-200}{2}\right)$$

$$\therefore 600 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(300)(750) + \frac{2}{3}\left(\frac{25}{1.5}\right)(a-200)(600)\left(650 - \frac{a-200}{2}\right)$$

$\therefore a = 223$ mm $\qquad \therefore a_{min} < a < a_{max}$

Get A_s From Compression Force = Tension Force

$$\boxed{C_{c1} + C_{c2} = T}$$

$$\therefore \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(300) + \frac{2}{3}\left(\frac{25}{1.5}\right)(223-200)(600) = A_s * \left(\frac{360}{1.15}\right)$$

$$\therefore A_s = 2619.4 \text{ mm}^2$$

<u>Check $A_{s_{min.}}$</u> $\qquad \therefore A_{s_{req.}} = 2619.4 \text{ mm}^2$

أصغر b

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 300 * 850 = 796.8 \text{ mm}^2$$

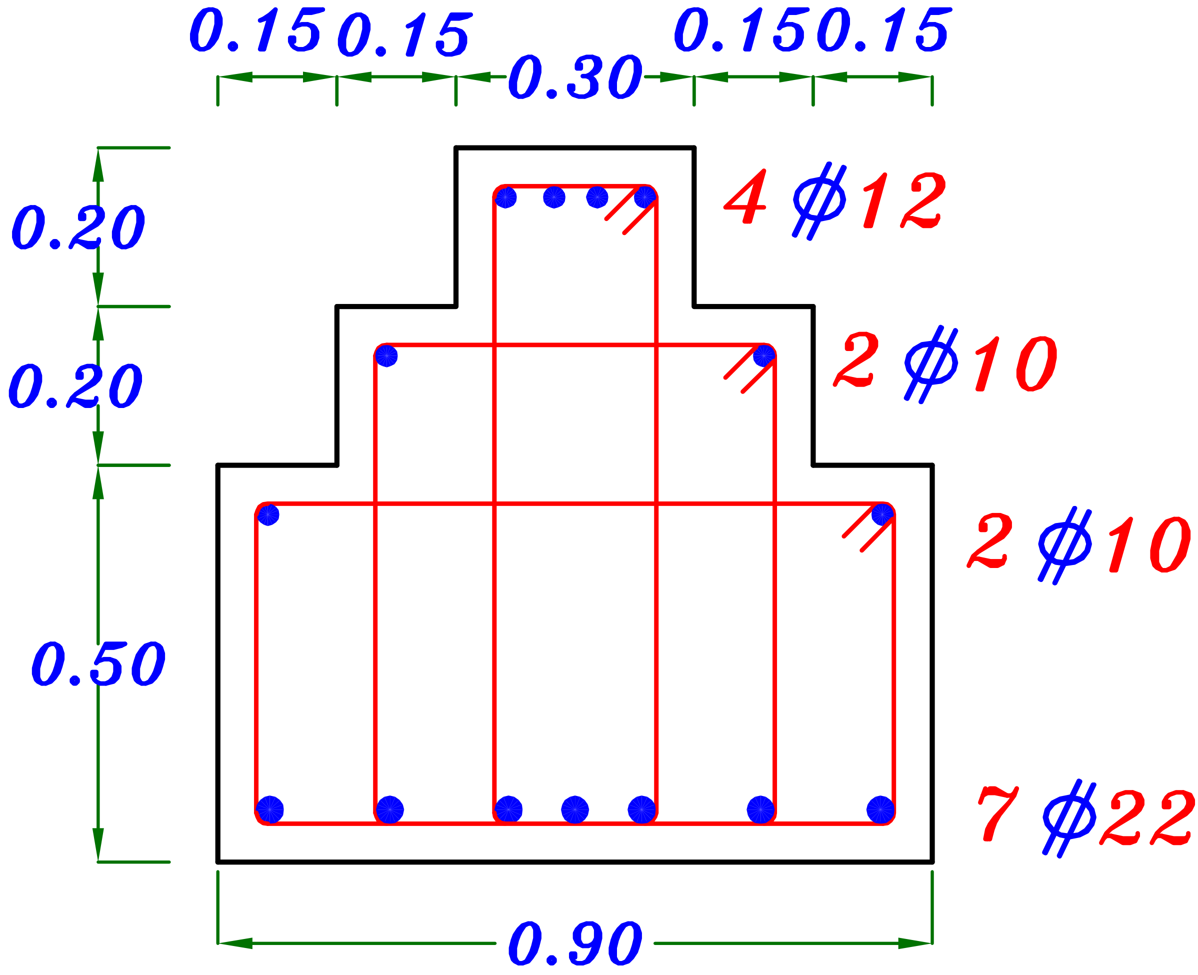
$\therefore A_{s_{req.}} > \mu_{min.}\, b\, d \qquad \therefore$ Take $A_s = A_{s_{req.}} = 2619.4 \text{ mm}^2$

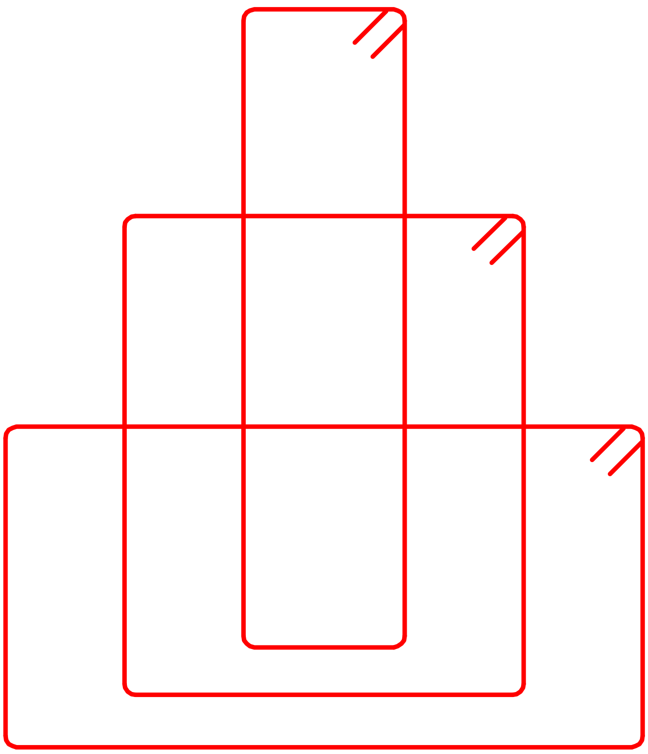
7 ϕ 22

$$\therefore n = \frac{b-25}{\phi+25} = \frac{900-25}{22+25} = 18.6 = 18.0$$

Stirrup Hangers $= (0.1 \rightarrow 0.2)\, A_s = (0.1 \rightarrow 0.2)\, 2619.4$

4 ϕ 12





5 ϕ 8 \m`

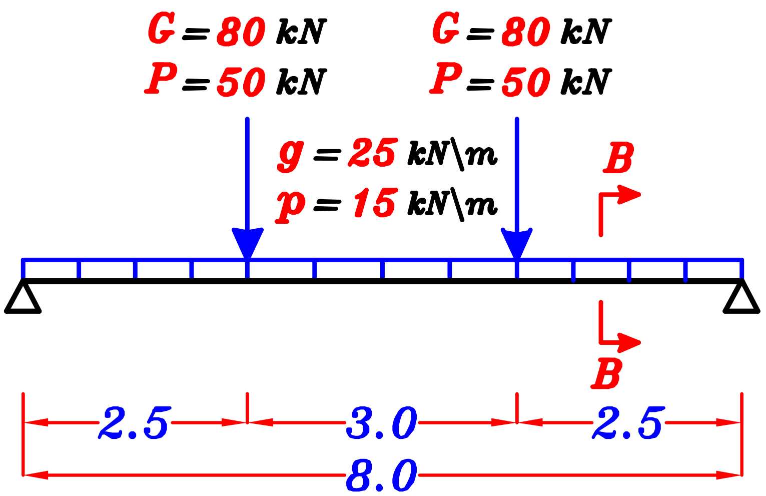
Example.

For the reinforced concrete simple girder carry the dead and live working loads and whose cross section is shown in Figure 1 It is required to:

1 – Using the First principles and the limit state design method, design the girder to satisfy the bending moment requirements.

2 – Draw the details of reinforcement of the girder's croos section to scale 1:25

Data : $F_{cu} = 25\ N\backslash mm^2$, st. 360/520



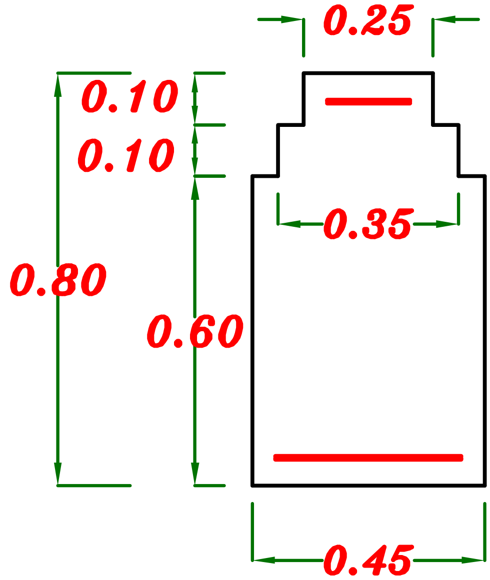
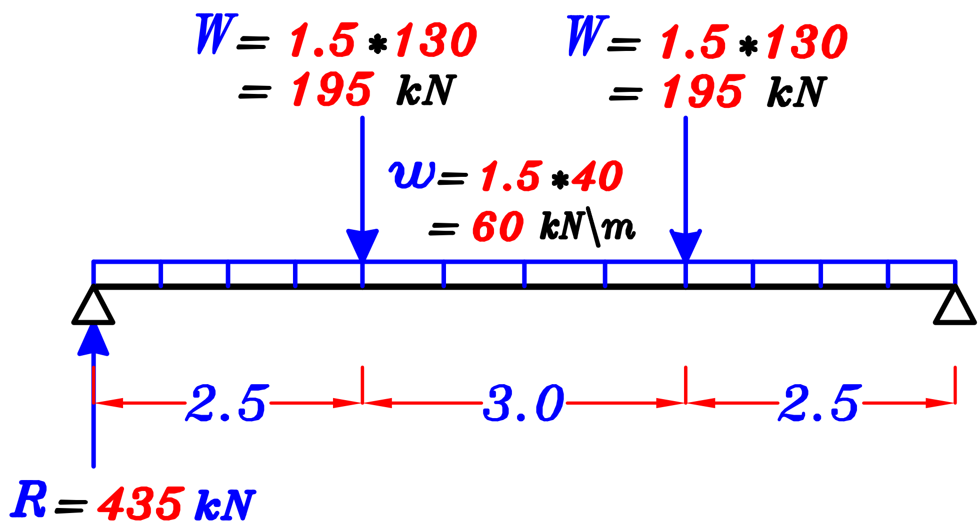
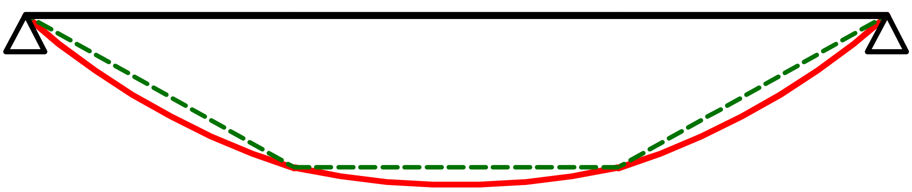


Figure 1

Cross Section B



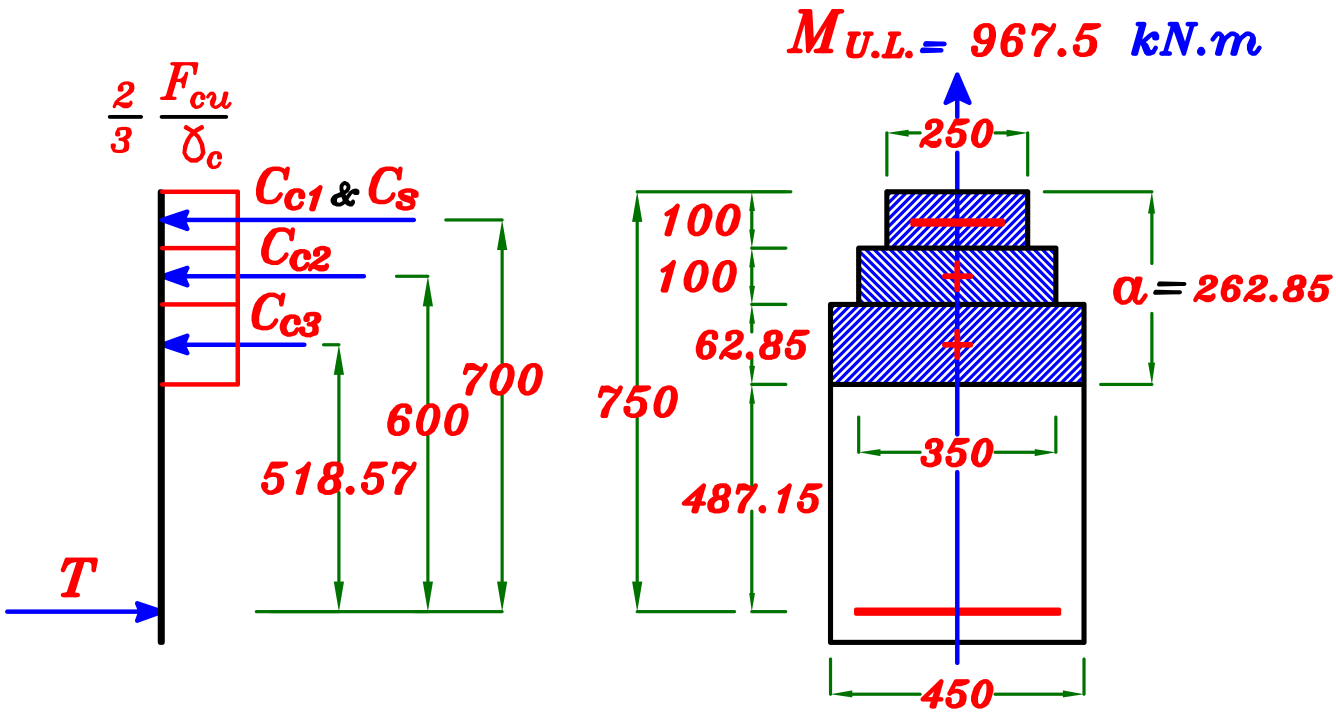


$M_{U.L.} = 967.5$ kN.m

$\because$ $A_{s'}$ is given.

$$\therefore a = a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600+(F_y \backslash \gamma_s)}\right] d$$

$$\therefore a = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600+(360 \backslash 1.15)}\right] 750 = 262.85 \text{ mm}$$



$$C_{c1} = \frac{2}{3}\left(\frac{25}{1.5}\right)(100)(250) = 277777.7 \text{ N} = 277.7 \text{ kN}$$

$$C_{c2} = \frac{2}{3}\left(\frac{25}{1.5}\right)(100)(350) = 388888.8 \text{ N} = 388.8 \text{ kN}$$

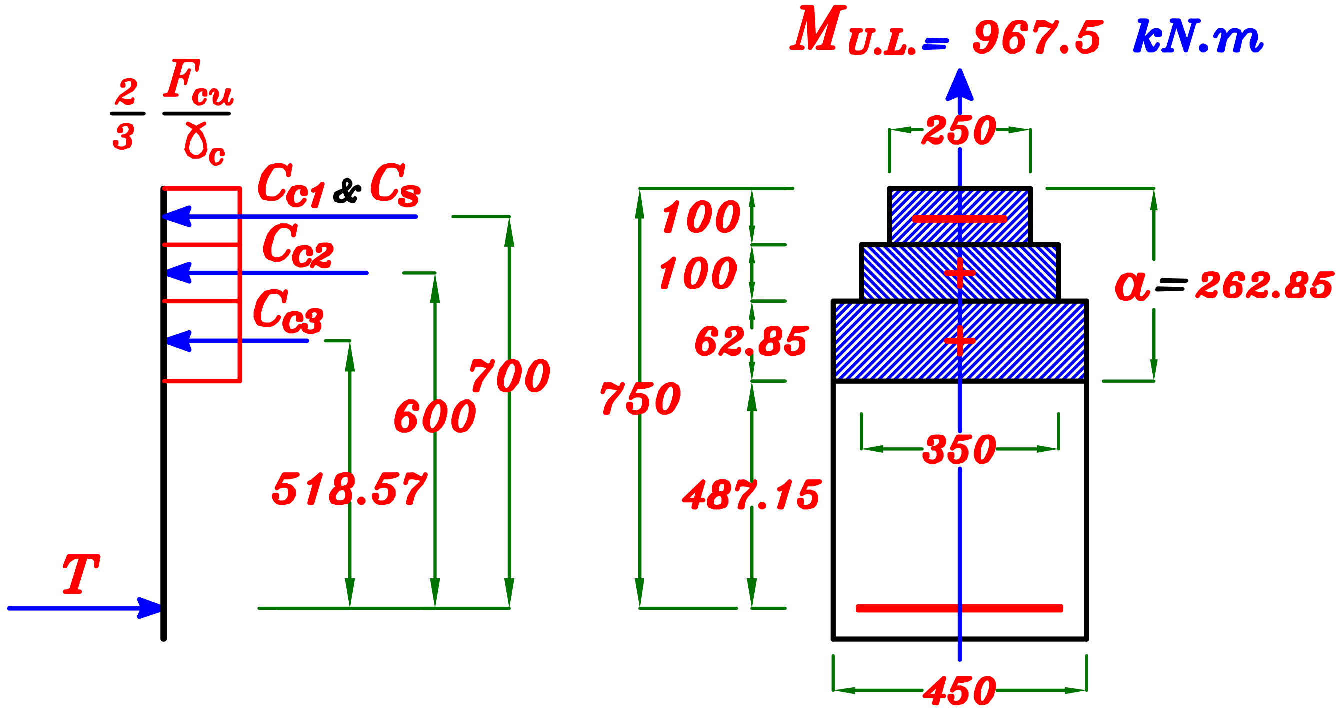
$$C_{c3} = \frac{2}{3}\left(\frac{25}{1.5}\right)(62.85)(450) = 314250 \text{ N} = 314.25 \text{ kN}$$

$$C_s = A_{s'}\frac{F_y}{\gamma_s} = A_{s'}\left(\frac{360}{1.15}\right) \quad , \quad T = A_s\frac{F_y}{\gamma_s} = A_s\left(\frac{360}{1.15}\right)$$

By taking the moment about tension steel.

$$* \; M_{U.L.} = C_s\,(700) + C_{c1}\,(700) + C_{c2}\,(600) + C_{c3}\,(518.57)$$

By taking the moment about tension steel.



$$* \; M_{U.L.} = C_s\,(700) + C_{c1}\,(700) + C_{c2}\,(600) + C_{c3}\,(518.57)$$

$$\therefore \; 967.5 * 10^6 = A_{s'}\left(\frac{360}{1.15}\right)(700) + 277777.7\,(700)$$

$$+\; 388888.8\,(600) + 314250\,(518.57) \longrightarrow \boxed{A_{s'} = 1719.34 \; mm^2}$$

$$\therefore \; n = \frac{b-25}{\phi+25} = \frac{250-25}{22+25} = 4.78 = 4.0$$

5 ϕ 22

$$* \; \textbf{Equilibrium equation.} \quad C_{c1} + C_{c2} + C_{c3} + C_s = T$$

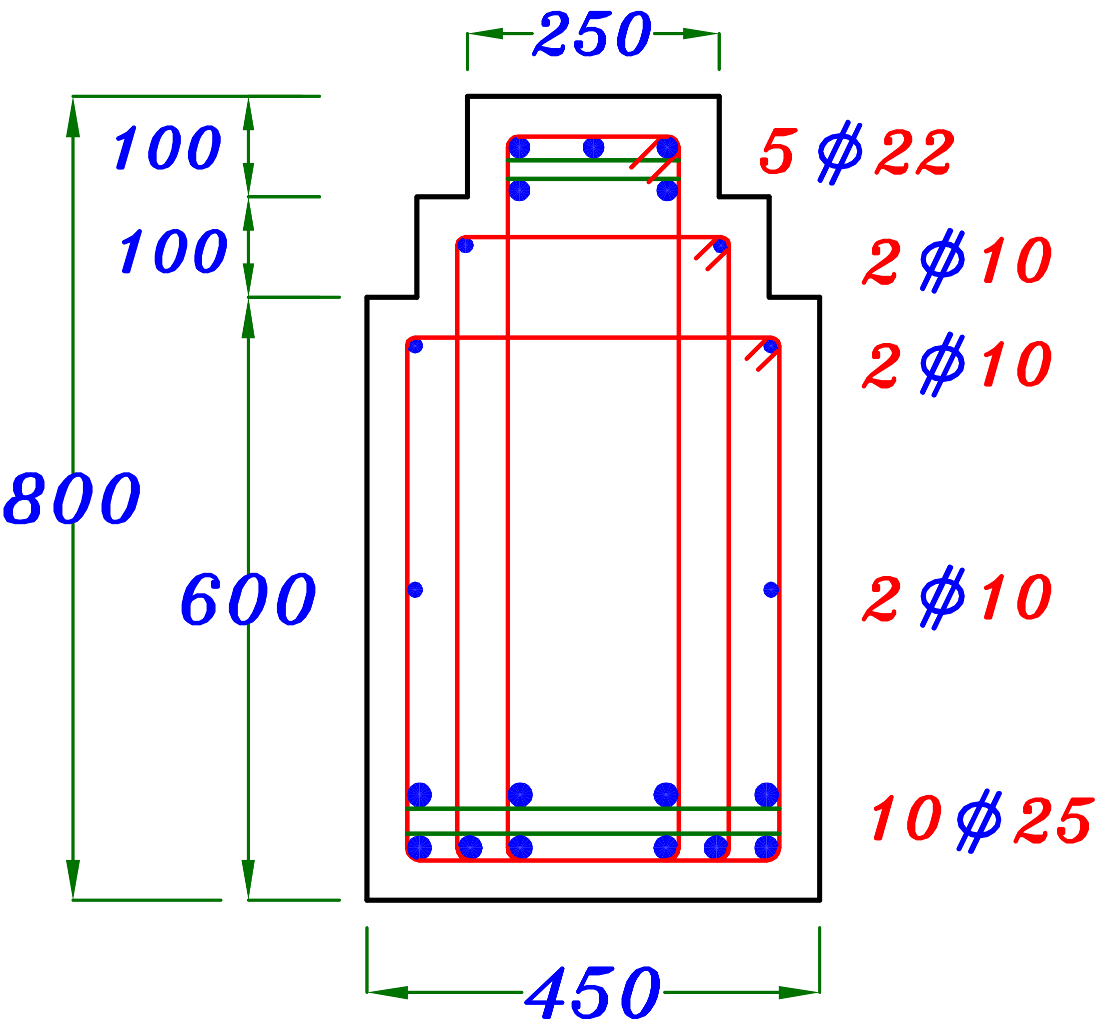
$$\therefore \; 277777.7 + 388888.8 + 314250 + 1719.34\left(\frac{360}{1.15}\right) = A_s\left(\frac{360}{1.15}\right)$$

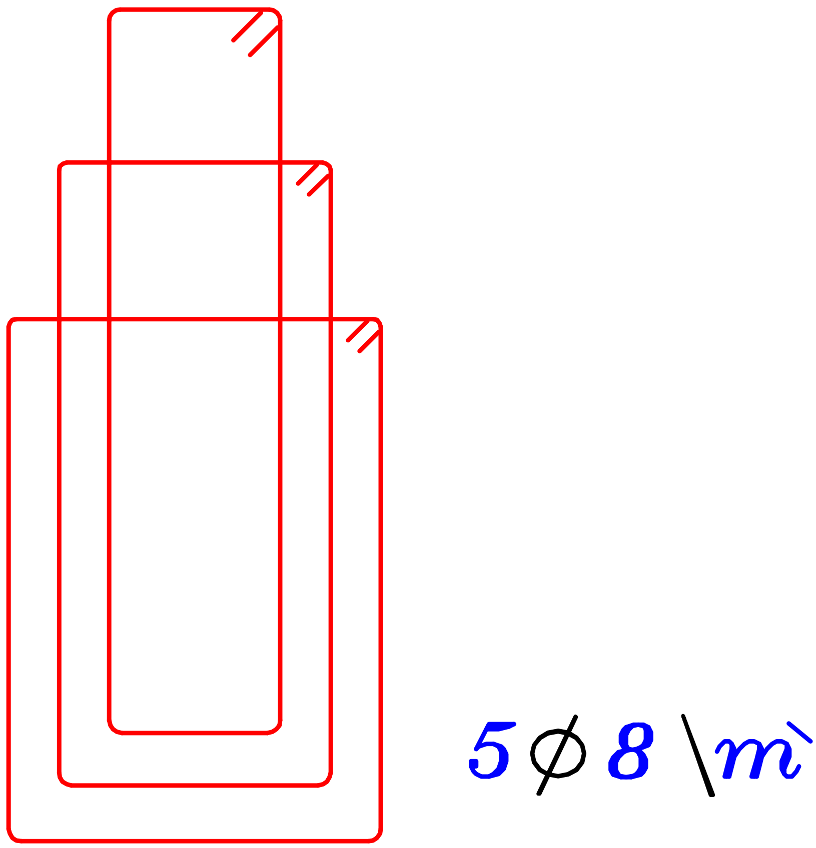
$$\longrightarrow \boxed{A_s = 4852.8 \; mm^2}$$

10 ϕ 25

$$n = \frac{b-25}{\phi+25} = \frac{450-25}{25+25} = 8.50 = 8.0$$

$$\text{Check} \quad \frac{A_{s'}}{A_s} = \frac{1719.34}{4852.8} = 0.354 < 0.4 \quad \therefore \text{ o.k.}$$


250
100
100
800
600
5 ϕ 22
2 ϕ 10
2 ϕ 10
2 ϕ 10
10 ϕ 25
450


5 ϕ 8 \m`

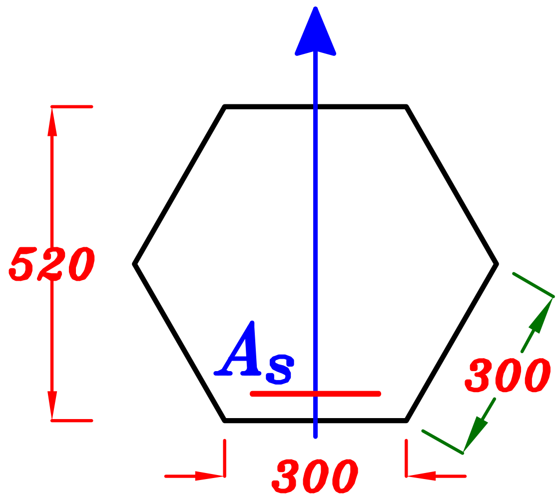
Example.

$F_{cu} = 25 \ N\backslash mm^2$

, st. 360/520

$M_{U.L.} = 250 \ kN.m$

Get A_s



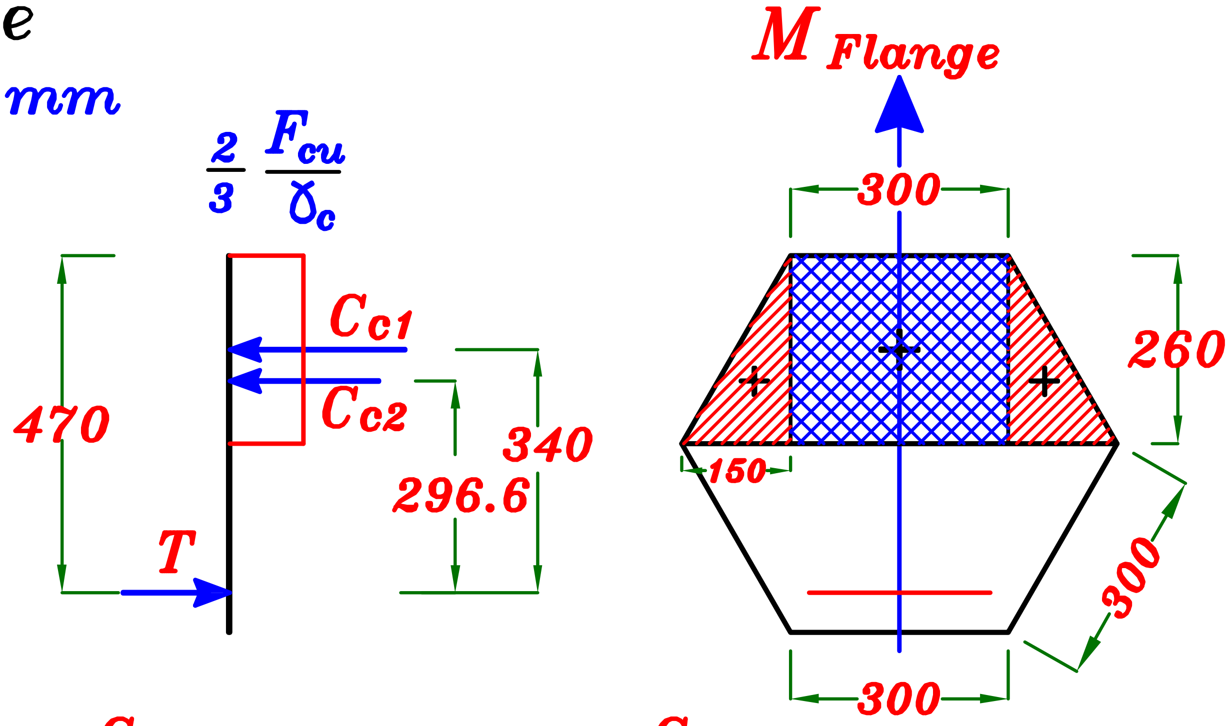
Solution.

$\because \ t = 520 \ mm \longrightarrow d = 470 \ mm$

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y\backslash \gamma_s)}\right] * d = 0.35\,d = 0.35 * 470 = 164.5 \ mm$$

Assume

$a = 260 \ mm$

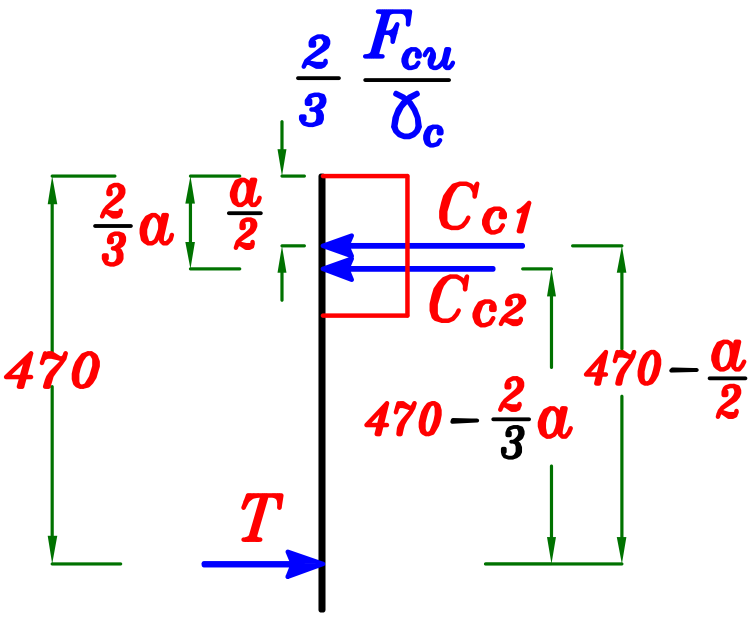


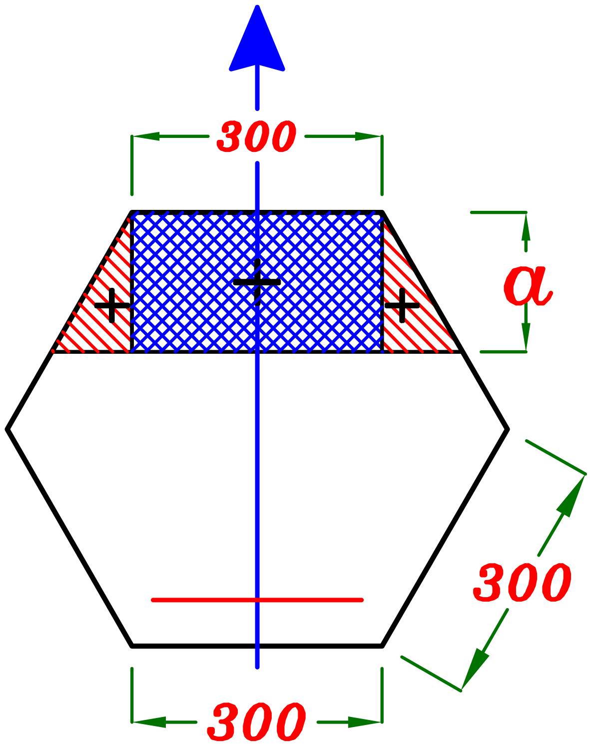
$$M_{Flange} = \underbrace{\frac{2}{3}\left(\frac{25}{1.5}\right)(260)(300)}_{C_{c1}}[340] + \underbrace{\frac{2}{3}\left(\frac{25}{1.5}\right) * 2(0.5)(150)(260)}_{C_{c2}}[296.6]$$

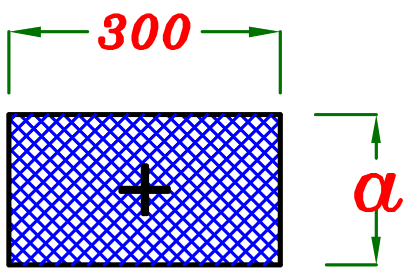
$$= 423193333 \ N.mm = 423.19 \ kN.m$$

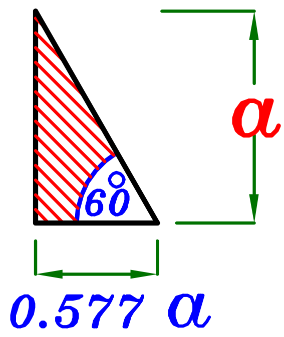
$$\therefore M_{U.L.} < M_{Flange} \longrightarrow a < 260 \ mm$$

$$M_{U.L.} = 250 \text{ kN.m}$$









area $A_1 = 300\, a$

area $A_2 = \frac{1}{2} * 0.577\, a * a$

$A_2 = 0.288\, a^2$

– Get a From

$$M_{U.L.} = \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\,(A_1)\,\left(d - \frac{a}{2}\right) + \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\,(2 * A_2)\,\left(d - \frac{2}{3}a\right)$$

$$\therefore\ 250 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(300\,a)\left(470 - \frac{a}{2}\right) + \frac{2}{3}\left(\frac{25}{1.5}\right)(2 * 0.288\,a^2)\left(470 - \frac{2}{3}a\right)$$

$a = 149.5$ mm $\qquad \therefore\ 0.1\,d < a < a_{max}$

Get A_s From Compression Force = Tension Force

$$\boxed{C_{c1} + C_{c2} = T} \qquad \frac{2}{3}\frac{F_{cu}}{\gamma_c}(A_1) + \frac{2}{3}\frac{F_{cu}}{\gamma_c}(2 * A_2) = A_s * \frac{F_y}{\gamma_s}$$

$$\frac{2}{3}\left(\frac{25}{1.5}\right)(300 * 149.5) + \frac{2}{3}\left(\frac{25}{1.5}\right)(2 * 0.288 * 149.5^2) = A_s * \left(\frac{360}{1.15}\right)$$

$$\therefore A_s = 2048.8 \ mm^2$$

Check $A_{s\,min.}$ $\qquad A_{s_{req.}} = 2048.8 \ mm^2$

b أصغر

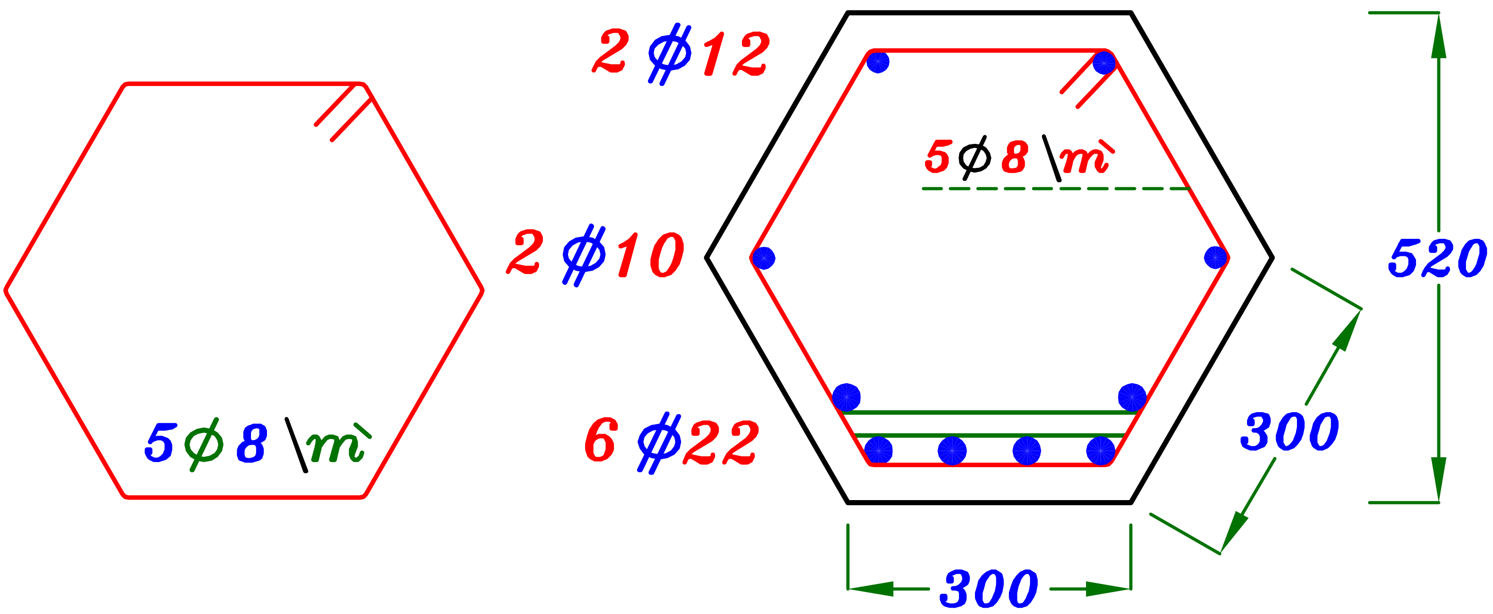
$$min.\ b\,d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\,d = \left(0.225 * \frac{\sqrt{25}}{360}\right) 300 * 470 = 440.6 \ mm^2$$

$\therefore A_{s_{req.}} > min.\ b\,d \qquad \therefore$ Take $A_s = A_{s_{req.}} = 2048.8 \ mm^2$

$$\therefore n = \frac{b - 25}{\phi + 25} = \frac{300 - 25}{22 + 25} = 5.85 = 5.0$$

6 ϕ 22

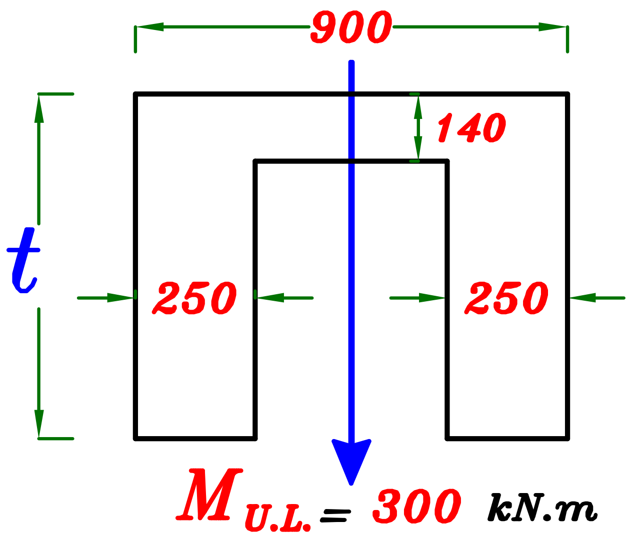
Stirrup Hangers = $(0.1 \rightarrow 0.2)\ A_s = (0.1 \rightarrow 0.2)\ 2048.8$ 2 ϕ12



Example.

$F_{cu} = 25\ N\backslash mm^2$, st. 360/520

$M_{U.L.} = 300\ kN.m$

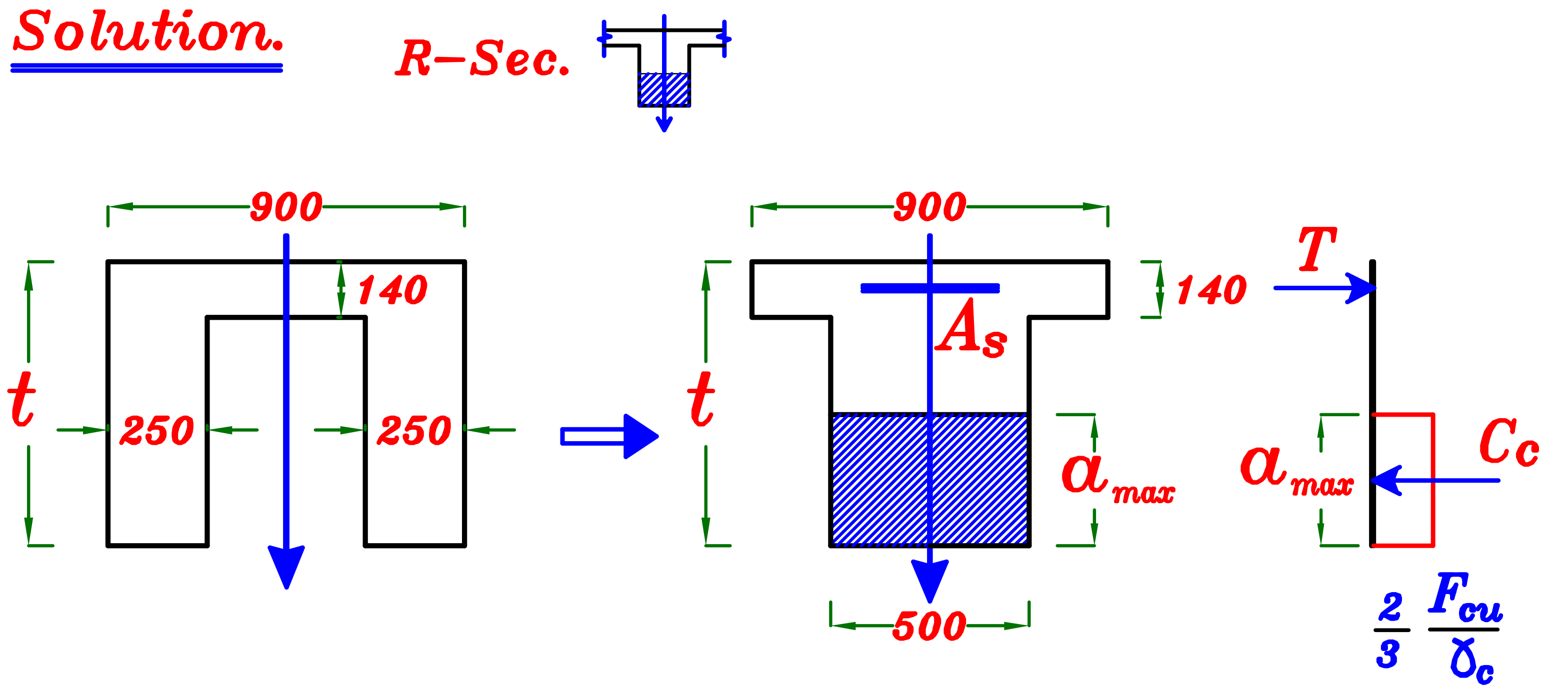


Req.

Using First Principles Design the Sec. For Bending
With min. Depth. & without $A_{s'}$

Solution.

R–Sec.



To get $d_{min.}$ $\xrightarrow{Take}$ $a = a_{max.}$, $A_s = A_{s\,max.}$

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y\backslash\gamma_s)}\right] * d = 0.35\ d$$

$$\mu_{max.} = 5 * 10^{-4} * F_{cu} = 5 * 10^{-4}(25) = 0.0125$$

$$A_{s_{max.}} = \mu_{max.}\ b\ d = 0.0125\,(500)\ d = 6.25\ d$$

From $$M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, a_{max.}\, b\left(d_{min} - \frac{a_{max.}}{2}\right)$$

$$\therefore 300 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(0.35\, d_{min})(500)\left(d_{min} - \frac{0.35\, d_{min}}{2}\right)$$

$$\therefore d_{min.} = 432.45\, mm \xrightarrow{Take} \boxed{d = 450\, mm}\,,\ \boxed{t = 500\, mm}$$

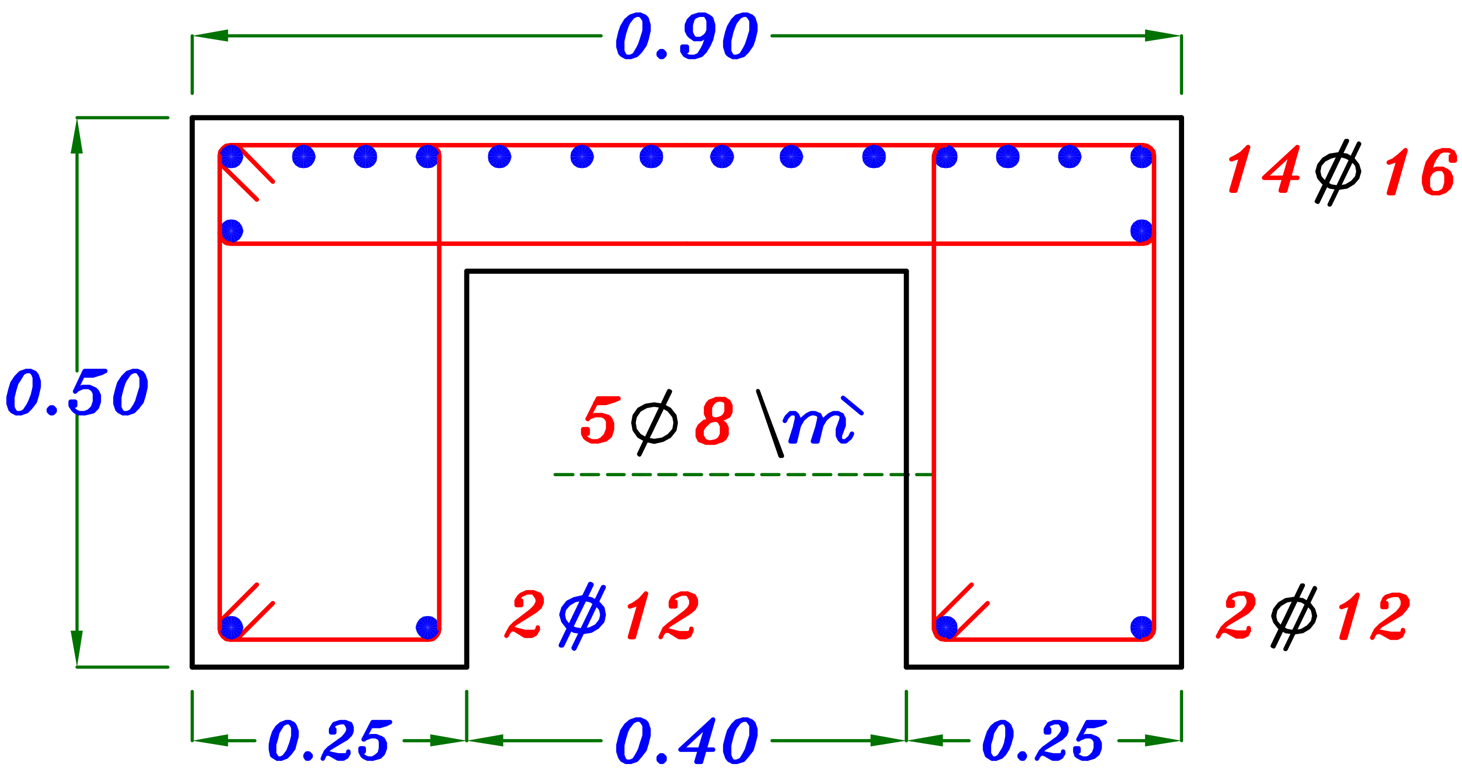
- Get A_s From

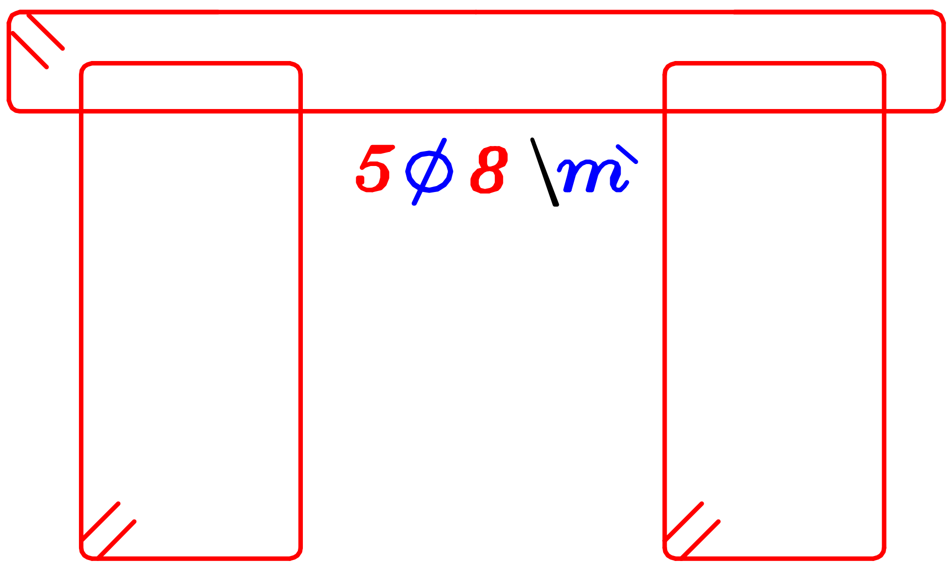
$$A_s = A_{s_{max.}} = 6.25\, d = 6.25\,(432.45) = 2702.8\ mm^2$$

$14 \phi 16$

$$\therefore n = \frac{b - 25}{\phi + 25} = \frac{900 - 25}{16 + 25} = 21.3 = 21.0$$

Stirrup Hangers $= (0.1 \rightarrow 0.2)\, A_s = (0.1 \rightarrow 0.2)\ 2702.8$ $4 \phi 12$

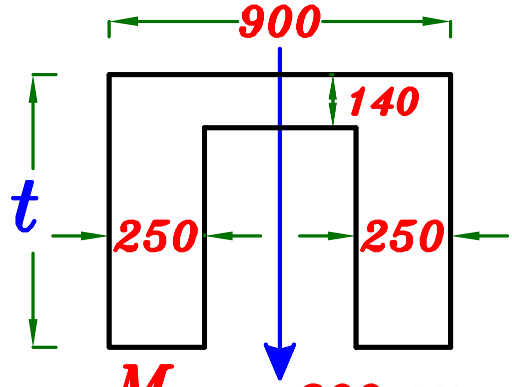

0.90
0.50
14 ϕ 16
5 ϕ 8 \m`
2 ϕ 12
2 ϕ 12
0.25
0.40
0.25


5 ϕ 8 \m`

Example.

$F_{cu} = 25\ N\backslash mm^2$, $st.\ 360/520$

$M_{U.L.} = 300\ kN.m$



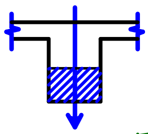
$M_{U.L.} = 300\ kN.m$

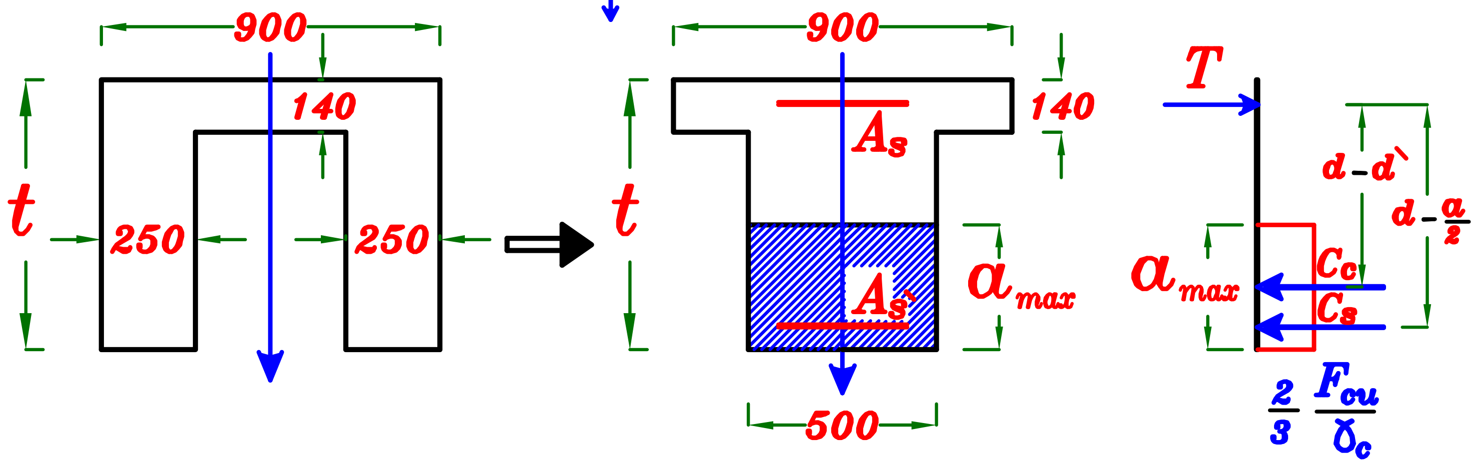
Req.

Using First Principles Design the Sec. For Bending With min. Depth. & with $A_{s`}$

Solution.

R-Sec.





To get $d_{min.} \xrightarrow{when} a = a_{max.}$, $A_s = A_{s\,max.} + A_{s`}$ , $A_{s`} = A_{s`\,max.}$

أكتب هذا الاثبات قبل حل المسألة

$$A_{s`max.} = 0.4\, A_s = 0.4\,(A_{s\,max.} + A_{s`max.})$$

$$\therefore A_{s`max.} = 0.4\,(\mu_{max.}\, b\, d + A_{s`max.})$$

$$\therefore A_{s`max.} = 0.4\,\mu_{max.}\, b\, d + 0.4\, A_{s`max.}$$

$$\therefore 0.6\, A_{s`max.} = 0.4\,\mu_{max.}\, b\, d$$

$$\therefore \boxed{A_{s`max.} = \frac{2}{3}\,\mu_{max.}\, b\, d}$$

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \gamma_s)}\right] * d = 0.35\, d$$

$$\mu_{max.} = 5 * 10^{-4} * F_{cu} = 5 * 10^{-4}\,(25) = 0.0125$$

$$A_{s_{max.}} = \mu_{max.}\, b\, d = 0.0125\,(500)\, d = 6.25\, d$$

$$A_{s`_{max.}} = 0.4\, A_s = \frac{2}{3}\, \mu_{max.}\, b\, d = \frac{2}{3}\,(0.0125)\,(500)\, d = 4.16\, d$$

From
$$M_{U.L.} = \frac{2}{3}\, \frac{F_{cu}}{\gamma_c}\, a_{max.}\, b\left(d_{min} - \frac{a_{max.}}{2}\right) + A_{s`_{max.}}\, \frac{F_y}{\gamma_s}\left(d_{min} - d`\right)$$

$$\therefore 300 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(0.35\, d_{min})\,(500)\left(d_{min} - \frac{0.35\, d_{min}}{2}\right) + (4.16\, d_{min})\left(\frac{360}{1.15}\right)(d_{min} - 50)$$

$\therefore d = 332.6$ mm $\xrightarrow{\text{Take}}$ $\boxed{d = 350\text{mm}}$, $\boxed{t = 400 \text{ mm}}$

- Get A_s From

$$A_{s_{max.}} = 6.25\, d = 6.25\,(332.6) = 2078.7 \text{ mm}^2$$

$$A_{s`_{max.}} = 4.16\, d = 4.16\,(332.6) = 1383.6 \text{ mm}^2$$ 4 ϕ 22

$$A_s = A_{s_{max.}} + A_{s`_{max.}} = 2078.7 + 1383.6 = 3462.3 \text{ mm}^2$$ 10 ϕ 22

$$\therefore n = \frac{b - 25}{\phi + 25} = \frac{900 - 25}{22 + 25} = 18.6 = 18.0$$